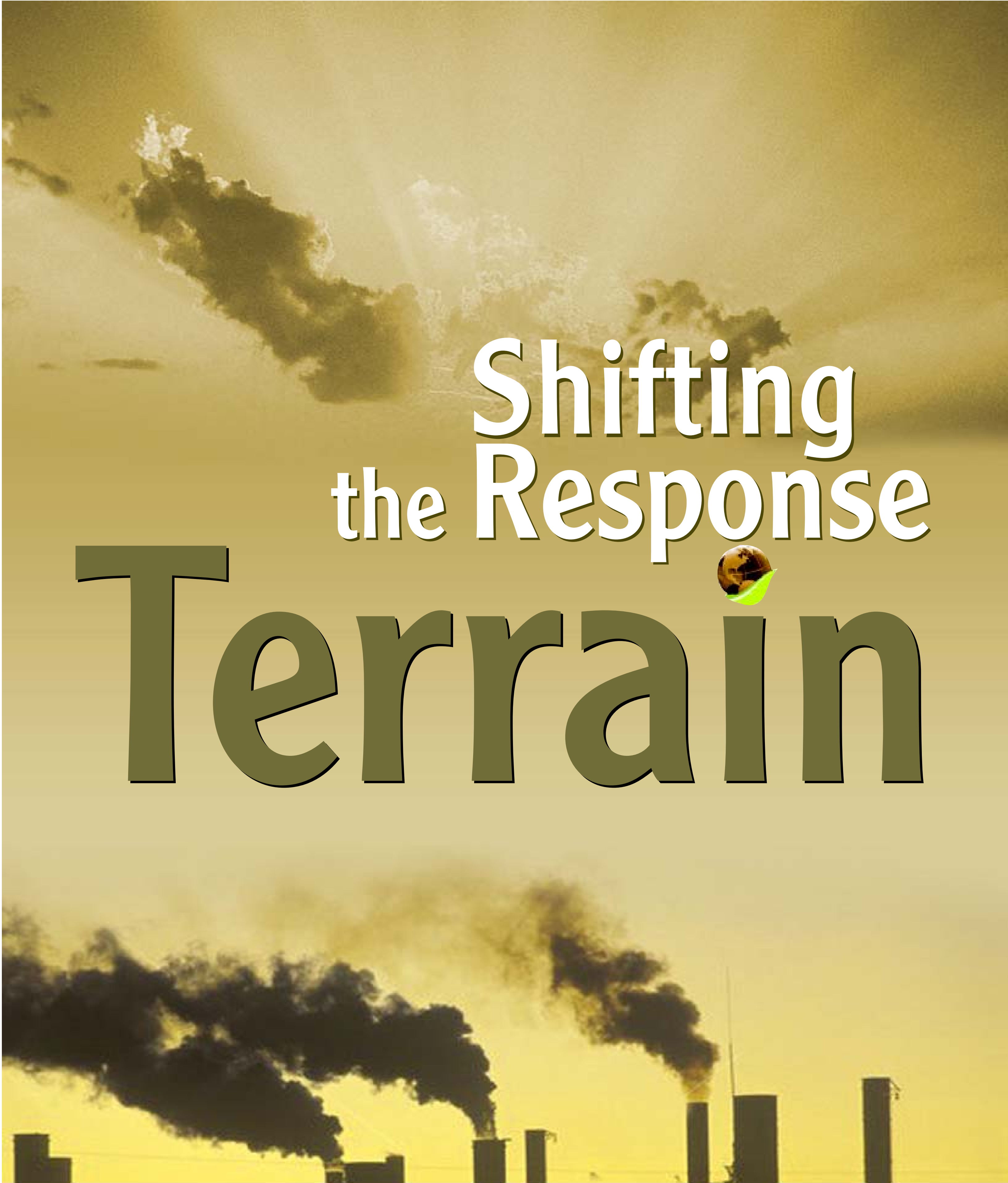

Shifting the Response Terrain

EDITORS

Sarah Opitz-Stapleton, Laura Seraydarian, Marcus Moench and Ajaya Dixit

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Preface

Anthropogenic green house gas emissions are leading to increases in global temperature with negative consequences in many parts of the world. South Asia is particularly at risk. Ecological zones such as the Himalaya, the arid plains and extensive coastal zones have high levels of direct exposure to the impacts of climate change. In addition, populations across the region are highly vulnerable. Many live in regions that already face the direct impact of floods, droughts and extreme storms. At same time many depend on climate vulnerable livelihoods such as agriculture and fishing and lack the financial and other resources essential to adapt.

Minimizing the impact of climate change on vulnerable populations and vulnerable regions within South Asia requires understanding both the natural dynamics of the systems affected by climate change and the functioning of human institutions.This publication presents twenty-two brief analytical pieces on climate science, shared learning process, vulnerability assessment, communication and ecosystems that contribute to such understanding.The pieces are based on research undertaken by a consortium of organizations working across South Asia.

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Content

Tracing the Threads of Understanding: Perceptions of Climate Change and Information Communication in Local Contexts

Marcus Moench & Sarah Opitz-Stapleton, ISET

The Challenge

Globally, research on climate dynamics and change generates new information and insights on an almost daily basis. This information has profound implications for human understanding of climate systems and the changes we face as climate conditions evolve, whether due to natural causes or anthropogenic forcing. These new insights, however, as with the climate systems themselves, often remain far above the ground - distant and divorced from the daily realities that shape lives, livelihoods and the responses of ordinary people to change. As a result, emerging insights rarely influence the behavior of those who are, perhaps, most vulnerable. The reverse is also true. Local populations generally have access to types of information and are aware of dynamics within local areas that are inaccessible to outside actors. There is a saying in the community of organizations working on emergency response that "all disasters are local." This saying points to the fact that whether one is dealing with floods, droughts, earthquakes or other events, the impacts of an event depends on a myriad of location-specific factors. Local topography, communications systems, the nature and maintenance of physical infrastructure, the presence of effective governmental and private organizations, social divisions – all such factors shape the humanitarian impact of "disaster" events in ways that are often far more fundamental than the physical event itself. Such location specific information is just as inaccessible to those working at a global level on changes in climate systems as the global information is to communities at local levels. As a result, in most cases, partial information and partial understanding interweave to shape perceptions and the decisions or courses of action different levels. The gulf between local knowledge and that generated at a global level by experts and other actors is wide. Understanding and perceptions diverge, complicating the emergence of proactive responses to climate change.

This paper traces the threads of understanding between emerging global scientific knowledge on climate change and local communities in India and Nepal. The paper summarizes the results of intensive research to explore the potential uses of existing "information products" on global climate change in local implementation contexts. The paper also explores the use of shared learning dialogues (SLDs) as a technique to bridge the gap between global and local knowledge in ways that support the evolution of practical strategies for responding to climate change.

Structure of the study

This study involves exploration of the uses and limitations of available climate information products in the development of strategies for adapting to climate change in a series of locations across India and Nepal. It was undertaken in conjunction with a major program supported by the Canadian International Development Research Centre (IDRC) in which local organizations are supporting the development and implementation of small-scale pilot projects to test the viability of different strategies for adapting to climate change. Case areas involved in the study included:

1. Coastal portions of Bhavnagar District, Gujarat, India. Pilot testing of climate information products in this case area was led by Utthan, an NGO with extensive experience in the region. Specific villages involved in the case are Tarasar, Sartanpar and Katpar.
2. Campierganj and Paniyara administrative blocks of Gorakhpur District of Eastern Uttar Pradesh, India. Pilot testing of climate information products occurred in the area between the Rohini and Gandak Rivers (tributaries to the Ganga) and was led by Gorakhpur Environmental Action Group (GEAG).
3. The Rohini and Bagmati River basins in the lower (plains) Tarai region of Nepal. Pilot testing of climate information products in this area was led by ISET-Nepal and Nepal Water Conservation Foundation.
4. Coastal areas of Tamil Nadu, including the villages of Pichavaram, TS Pettai, Vanagiri, Pushpavanam and the Sonankuppam area of Old Town Cuddalore. Pilot testing in these areas was led by the Madras Institute of Development Studies (MIDS).

The project began with an in-depth review of available climate information products with particular emphasis on the monsoon system, sea-level rise, and the availability of global climate change scenario projections relevant to the local case areas. With the exception of the monsoon system and general projections of climate change impacts on the All-India Monsoon, for which ISET developed a synthesis chapter (Opitz-Stapleton 2008), little detailed information for the specific case sites was easily available beyond the general scenarios published in the IPCC (IPCC 2007). Policies governing the development and dissemination of information on climate and weather information in the case countries were also reviewed with the core finding being that official sources of information are highly centralized in organizations such as the India Meteorological Department (IMD) and, while information often is available from other sources, it is not publicly available and can not be used as a basis for official decision making.

Following the above reviews, extensive discussions were held within the project to assist partner organizations in developing as much understanding as possible regarding the projected regional impacts of climate change. The partner organizations then engaged local communities and key regional actors in dialogue regarding the implications of climate change for their local areas. The goal was to assist both local communities and the partner organizations themselves in understanding the implications of climate change, integrating that with local insights and using the combination of insights generated to develop location-specific response strategies. This was done through an intensive series of shared learning dialogues (SLDs) designed to bring global information on climate change together with local information on hazards and climate-related conditions. Overall, the project was designed to explore *both* the way climate information products could be used in developing location specific studies *and* the gaps in understanding that exist at various points in the chain between local and global knowledge sources and the use of that knowledge.

Key Findings

Perhaps the single most important lesson to be drawn from the project is the difficulty inherent in communicating different types of knowledge across major cultural, educational and other boundaries. This is nothing new but it has profound implications. Very basic distinctions, such as the difference between weather and climate, may remain as gaps in understanding even for relatively high-level organizations that are directly involved in work on global climate change. The foundations for this gap can be deeply coded in the structure of language. Hindi, the regional language of much of northern India, for example, has only one word *mausum* that applies both to weather and climate. The distinction between the short-term variations in rainfall, temperature and other events that are captured by the English language concept of weather and the longer-term underlying properties of the climate system from which weather events emerge isn't part of the cognitive space enabled by the language. In the absence of such a distinction, even after extensive exposure to information from global research on climate change, individuals in regional organizations and local communities tend to equate climate with weather. Partially as a result, when discussing climate they focus on any changes in weather they have observed and emphasize response strategies, such as the improvement of weather forecasting and early warning systems, that relate to weather conditions.

The challenge is compounded by the very limited array of climate "information products" available that are targeted toward regional contexts and, more profoundly, by the types of information on climate change currently produced by the global scientific community. As discussed further below, available "climate information products" consist primarily of scientific studies (papers in journals) supplemented by a scattering of, often difficult to access or interpret, maps and studies. Such information is not easily understood by individuals without climate science backgrounds and not accessible to those without journal subscriptions. This is clearly illustrated by the analysis of changes in the Indian monsoon (Opitz-Stapleton 2008).

In addition to the scattered nature of available information, communication faces a further fundamental challenge due to fundamental differences between the types of information local actors "would like to have" and the types of information produced by the global scientific community. Individuals and organizations within regions seek certainty and specificity – they want to know *what* will happen, *where,* and *when.* Information produced by the global scientific community rarely provides this. This isn't just related to the scientific and socio-economic behavioural uncertainties inherent in producing climate change projects with general circulation models (GCMs) and downscaling those projections to make region-specific projections. While these issues are important, much of the challenge is related to the nature of emerging scientific knowledge on climate change and how it is communicated. Scientific findings that point toward increased variability in climate conditions and uncertainty in our carbon future indicate that the demand for specific projections can, for many dimensions of climate change, never be met. As a result, the core challenge relates to the need for communicating and responding to uncertainty and variability to multiple, non-technical users rather than specificity. Uncertainty and variability are practically and conceptually much more difficult than the communication of specific projections would be.

The above complexities highlight the need to develop *processes* for communicating emerging climate information into local contexts and integrating global and local knowledge sources. While additional information on the likely impacts of climate change is important, it will be of little use for informing practical responses unless processes for communication can be developed that are capable of responding to the disjuncture between user demands for specificity and inherent scientific uncertainties. The SLD process piloted in this project and other experiments with information communication through, for example, radio dramas represents an initial step in this direction. As clearly illustrated in separately published case studies from Tamil Nadu, eastern Uttar Pradesh and Gujarat (Moench and Dixit [Eds.] 2007), while the shared understanding generated through SLDs is partial at best, it can serve as a basis for identifying courses of action that should assist local areas in responding effectively to some of the projected consequences of climate change. Before describing the SLD process in detail, however, it is essential to review available information on climate change in South Asia.

The Climate Information Context in South Asia

The two most comprehensive, but also somewhat dated, sources of information on climate change in South Asia are the reports of the IPCC and India's National Communication to the UNFCCC. These findings are summarized briefly below starting with a brief discussion of the somewhat older findings of India's first national communication (NATCOM) and the institutions that produced it. Additional sources of information include journal articles published by primarily Indian scientists at the Indian Institute of Tropical Meteorology (IITM – Pune) and the India Meteorological Department.

India's First National Communication on Climate Change

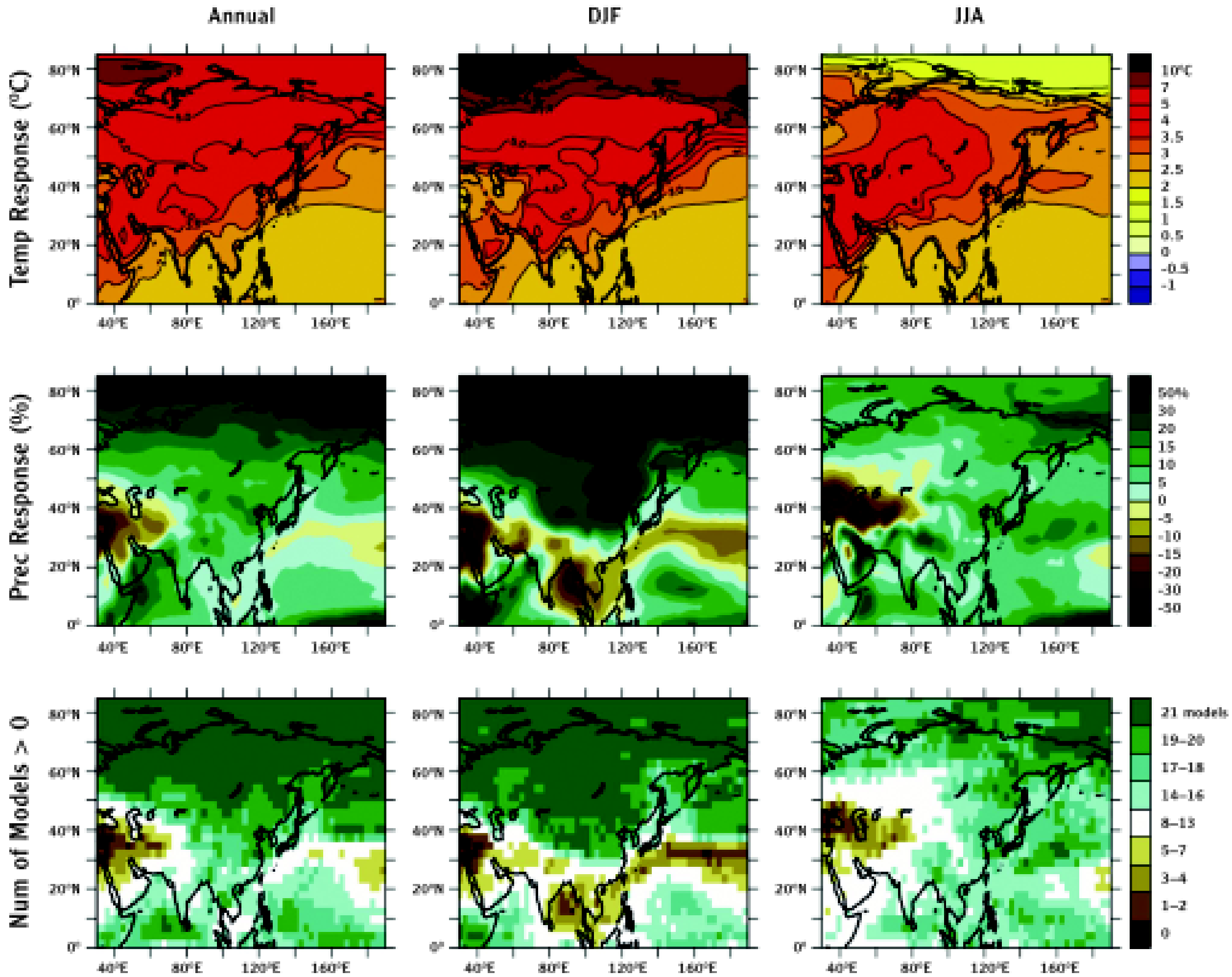
As part of India's National Communication to UNFCCC, the first NATCOM made relatively macro-level projections of potential changes in climate for India. These projections suggested that there would be little change in overall monsoon rainfall, but that the frequency of heavy rainfall events over major parts of the country would increase. In addition, the projections suggested a potential overall decline in rainfall across significant regions that could be accompanied by reductions in dry season flows for major rivers. Where temperatures were concerned, analyses undertaken for the first NATCOM suggested increases in average temperatures ranging from 2.3° C to 4.8° C with a doubling in CO_2 concentrations. Some estimates also predict a change in the mean maximum and minimum surface air temperatures of 0.7° C and 1.0° C over land by the 2040s, compared to the 1980s (IPCC 2007). In addition to changes in temperature and precipitation, the NATCOM found that, over the short-term, the melting of Himalayan glaciers would increase overall flows and the incidence of flash floods. Over the longer-term, however, the discharge from Himalayan river systems would drop as snow and glacier covered areas decrease, potentially turning perennial rivers into seasonal ones. Where coastal areas were concerned, it was projected that sea level could rise by 0.5 meters. In addition to projecting large-scale changes such as the above, the NATCOM developed a series of national level impact assessment studies on the following key thematic areas: water resources; agriculture; forests and other natural ecosystems; coastal zones; human health; energy and infrastructure.The NATCOM report and its findings have been widely disseminated through publication and series of workshops.The second NATCOM, which is now being prepared, has plans to downscale climate change projections to local areas. These projections are, however, not publicly available.

Climate change projections aside, systems for collecting and generating climate and weather information in India are fairly extensive. Four agencies have primary responsibility for generating such information: the Central Water Commission (CWC); the India Meteorological Department (IMD), the National Centre for Medium Range Weather Forecast (NCMRWF); and the Indian Institute of Tropical Meteorology (IITM). The CWC monitors river flows and issues water level and inflow forecasts for operation of some major reservoirs, principally in flood prone states. It focuses heavily on flood forecasting and warning. Information from these forecasts is then transmitted to relevant state-level authorities and other agencies connected with flood protection and management using telephones, special messengers, telegrams, and wireless. How it is transmitted in any given circumstance depends on the flood situation and existing communication facilities. IMD is the premier weather forecasting institution in the country. It monitors weather conditions and provides current information targeted to weather sensitive sectors, such as agriculture and irrigation, and to the general public. In addition, it provides a number of services tailored to the needs of the agriculture sector in general and farmers in particular. This includes 48-hour weather forecasts through the Farmers Weather Bulletins and the Agrometeorological Advisory Service in consultation with agriculture experts working in state agriculture departments. It also produces longer-term crop weather calendars. More generally, the IMD has a major role in projecting and providing early warning regarding severe weather phenomena such as tropical cyclones, heavy rains, cold and heat waves. Finally the IMD conducts research in meteorology and related disciplines. In comparison to the IMD, the NCMRWF has a more limited and targeted focus. It provides medium range weather forecasts using deterministic methods and also supports the Agro Advisory Service for farmers. Finally, the IITM functions as a national centre for basic and applied research in monsoon meteorology of the tropics in general with special reference to monsoon meteorology of India and the surrounding regions, as well as studying the impacts of climate change and landuse change on the Indian monsoon system.

While the above institutions generate substantial weather and climate related information, major issues exist regarding the effective communication and use of such information for reducing disaster risk and adaptation to climate change. In many situations, the information is transmitted in formats that are difficult for users to understand. Furthermore, as with climate information in general, there is mismatch between the scale of data production and the scale needed for making effective decisions. While substantial research is being undertaken by organizations operating at a national level in India on climate change and this is being utilized in the preparation of India's second national communication to the UNFCCC, projections are not available or accessible that address changes at local or sub-regional scales. The limited availability of such projections, combined with their inherent uncertainty, represent key factors inhibiting the integration of such information in the activities of different sectoral ministries.The Ministry of Water Resources, for example, continues to rely on historical hydro-meteorological information for designing flood control and mitigation structures even though it is well known that such information can not be relied on as an indication of future conditions.

Findings of the IPCC for South Asia

According to the most recent IPCC report (IPCC 2007), annual and seasonal warming of South Asia is expected to be above the global mean projections.Warming trends have strong seasonal and geographical differences. Geographically, warming is projected to be less in Southern India (~2.5°C around Tamil Nadu) and to be up to 4°C above the historical annual mean as one moves northward over the Tibetan Plateau (see Figure 11.9 below, from IPCC 2007: 883).Warming is much more pronounced in the winter (December - February) and summer (March - May) months than during the monsoon season.This could have significant repercussions for winter crops, especially as drying is also projected during winter and could indicate greater drought probability. Warming is less pronounced during the monsoon season ("only" about ~2.5°C) over the wider South Asia region, but is enough to impact convective processes during the monsoon and increase the probability of extreme intensity, short duration precipitation events.The IPCC specifically found that: "There is *very likely* to be an increase in the frequency of intense precipitation events in parts of South Asia, and in East Asia. Extreme rainfall and winds associated with tropical cyclones are *likely* to increase in East Asia, Southeast Asia and South Asia." (IPCC 2007: 850). Generally, the GCMs surveyed by the IPCC are in stronger agreement about warming amounts and spatial temperature trends than they are with regard to precipitation.



Temperature and precipitation changes over Asia from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom row: number of models out of 21 that project increases in precipitation.

In terms of precipitation projections, the IPCC projects the following for the broad region of South Asia:

		Temperature Response (°c)						Precipitation Response (%)						Extreme Seasons (%)		
Region	**Season**	**Min**	**25**	**50**	**75**	**Max**	**T yrs**	**Min**	**25**	**50**	**75**	**Max**	**T yrs**	**Warm**	**Wet**	**Dry**
SAS	DJF	2.7	3.2	3.6	3.9	4.8	10	-35	-9	-5	1	15		99		
	MAM	2.1	3.0	3.5	3.8	5.3	10	-30	-2	9	18	26		100	14	
5N, 64E	JJA	1.2	2.2	2.7	3.2	4.4	15	-3	4	11	16	23	45	96	32	1
to	SON	2.0	2.5	3.1	3.5	4.4	10	-12	8	15	20	26	50	100	29	3
50N, 100E	Annual	2.0	2.7	3.3	3.6	4.7	10	-15	4	11	15	20	40	100	39	3

Excerpt of Table 11.1 for South Asia projections from Chapter 11 of IPCC (2007) Working Group 1.

As shown in Figure 11.9 and Table 11.1, there is quite a range of precipitation projections for the region and large spread in model agreement. The IPCC surveyed the projections of 21 different GCMs and agreement between models on precipitation projections, both in timing and amount, is not as strong as in other regions of the world. Even in other regions, however, precipitation remains one of the most difficult variables to project as its formation depends on complex physical interactions that are not completely understood or captured by models. As the IPCC report states:

> "Most of the MMD-A1B models project a decrease in precipitation in DJF (the dry season), and an increase during the rest of the year. The median change is 11% by the end of the 21st century, and seasonally is –5% in DJF and 11% in JJA, with a large inter-model spread (Table 11.1). The probabilistic method of Tebaldi et al. (2004a) similarly shows a large spread, although only 3 of the 21 models project a decrease in annual precipitation." (IPCC 2007: 884)

Broadly, precipitation is expected to increase during the monsoon months of June-August and in the post-monsoon season of September-November. Precipitation is projected to decrease during December-February and slightly increase in March-May. Additionally, precipitation variability and extreme precipitation events are projected to increase. However, the topography of the Indian sub-continent is quite diverse and greatly influences the convective processes embedded within the monsoon. This diversity in rainfall timing and amount is not adequately captured by the low-resolution GCMs synthesized in the IPCC reports. Thus, as seen in a separate study we conducted for the Rohini Basin (Opitz-Stapleton et al., in press), and other Indian climate change studies (Mani et al. 2009; Kripalani et al. 2007; Kumar et al. 2006), regional projections for climate change vary more than the broad IPCC projections.

The Contrast with Local Perceptions

Findings of the IPCC and assessments such as those underlying India's national communication to the UNFCCC are, as the sections above demonstrate, quite general. There is strong agreement that temperatures will increase. Projections regarding changes in precipitation, while suggesting increases for the region as a whole, show far less agreement. Although non-specific in nature, there also appears to be a general consensus that variability and the potential for extreme storm events are also likely to increase.

In some ways, the above findings contrast significantly with the perceptions of local organizations and the communities they work with. In other ways, however, they are consistent. Communities often express a sense of change in the predictability and variability of the weather and seasonality that, while impressionistic, are consistent with the general finding from the IPCC and India's own analyses. Where contrasting perceptions are concerned, as illustrated in the accompanying box written by partners working in the Gujarat case site, the divergence isn't just about the information itself or the perceptions of actual changes in climate but also relates to issues of control over information and the uses to which it is put.

At present, most research on climate change is targeted either toward improving basic scientific understanding or influencing policy environments, such as the ongoing global negotiations over the successor to the Kyoto protocol. As a result, the context in which analysis of the impacts of climate change is occurring is, to a large extent, directed upward toward often heavily politicized policy environments rather than downward toward the communities of actors at local levels who might be able to use such information in more applied contexts. This orientation may in its own right be as important a factor contributing to the gap between local impressions of climate change and the perspectives emerging from higher-level scientific analysis.

What types of perspectives on climate change did the project encounter in interviews with local communities across our pilot areas? Common elements were often contradictory and included:

1. A general perception that, in often subtle ways, rainfall, temperature and wind patterns are changing in ways that affect primary agricultural or fishing livelihoods and the behavior of birds, fish and other wildlife;
2. In coastal areas, an impression that saline water is intruding inland and that coastal livelihoods, particularly those based on agriculture, are being affected;
3. That climate change is a remote event that is primarily important at a global level and of less relevance than access to reliable services for drinking water, sanitation, health and education or the resolution of unrelated regional problems such as conflict;
4. That climate and weather are the same thing — discussions on climate change often transited almost immediately into debates over weather forecasts and the need for early warning systems; and
5. That local sources of knowledge are far more reliable than official weather forecasts or projections for both weather and longer-term changes in climate.

Perception of the Villagers about Climate Change and Variability

In coastal Gujarat, fishing communities have been living on the seashore throughout historical memory. As a result, they have evolved their own perceptions regarding climatic variability and change. The coastal communities have their own language concerning climate change and the impact it is perceived as having on their livelihoods. According to detailed interviews with local fishermen, the sea is behaving in an erratic manner that has changed substantially from their historical experience. Wind velocity has increased and there is an increase in heat waves. Mohanbhai babulbhai Baraiya, a fisherman from Katpar village (located on the coast of gulf of Khambat in Gujarat), succinctly pointed out that, "due to irregular wind and monsoon patterns, a feature of the last 2-3 years, we are facing problems. Now fishermen cannot now go to deep seas regularly for fishing" (Interview by the team). Mohanbhai, also stated that "climate changes are occurring and as result, for the last two years there is increase in heat waves. The occurrence of rain has also been affected." In a similar way, Jayantibhai, of Bandar area of Katpar, village, categorically states, that, "the impact of climate change can clearly be seen. Earlier the wind use to flow in one direction but now the direction of the wind is not constant, its changing all the time, as a result the fish availability has decreased" (Personal interview with the fisherman, May 3, 2007: visit to Katpar village). He also pointed out that for the last five years the summer temperature has increased. This has impact on their livelihood pattern. The fish catch is less and so they have to work as labourers in nearby villages. As a result, Jayantibhai would like to diversify his income away from fishing by doing other jobs. In similar vein, Kuverben Chavada points out, that "for the past two years, there is an increase in heat waves, and more water during floods. And winters are less cool as compared to earlier times."

Perspectives such as those of the local villagers quoted above could be dismissed as impressionistic and uninformed. To do so would be a grave mistake. *First*, individuals such as fishermen are intimately acquainted with local conditions in ways that global science never can match. The details they observe and the impressions they generate may capture signals of change far before the long-term monitoring systems required for scientific inquiry are able to collect sufficient data to detect the signals of changing climate. *Second*, even if local perceptions are based on impressions rather than documented change, these impressions inform behavior in far more profound ways than global information currently can. The desire to diversify his livelihood away from fishing that was expressed by Jayantibhai and obtain other work is a major dynamic across the Indian and, in some ways, global economy. As people respond to that desire, whatever its ultimate cause, their vulnerability to climate change shifts in profound ways. From dependency on the subtleties of weather and water as the basis for a fishing based livelihood, Jyantibhai could join the millions of laborers working in sweat shops where their primary climate vulnerability might shift to global food prices or the ability to afford air-conditioning.

As the behavior of communitites at local levels illustrated above indicates, understanding the sensitivity and vulnerability of the environment and society to climate change is as critical as understanding climate itself. Expertise that links local understanding of disasters, health systems, water resources, agriculture, energy and fisheries is essential if climate information is to be translated into meaningful parameters for decision makers, policy makers and the general public. Global 'knowledge' about climate change and the implications that has for disasters and the vulnerability of local communities has, however, rarely been transmitted beyond scientific and policy groups in research organizations and central government ministries. Adaptation to climate change and variability requires dissemination of information in ways that reach local levels. The governance of information on climate change in South Asia is, however, deeply embedded in a state-centric geopolitical context that often inhibits information flow. High levels of uncertainty concerning the specific impacts of climate change, coupled with the potentially large implications such impacts may have for society, pose major challenges for politicians and policy makers. Such actors must balance the potential consequences of inaction with the, often far more immediate, political consequences of acting on information in ways that are likely to prove unpopular. In addition, there is the often justified fear that dissemination of incorrect information could undermine the legitimacy of information providers or catalyze inappropriate responses. This concern has always been present with weather forecasting and is a major factor behind the centralization of forecasting authority in many countries. Finally, the global context has major implications for information flow. With negotiations over emissions reductions, the role of energy use in economic development and the impacts of climate change on developing countries occupying center stage in global political relations, information on climate change has direct implications for national strategic interests. As a consequence of these multiple influences, detailed information concerning climate change and its likely consequences tends to be confined to scientific and policy making circles.

Limitations on the flow of information exacerbate gaps in perception between actors directly involved in global debates over climate change and local communities. Local communities do have strong impressions regarding climatic conditions and patterns of change. Their understanding, however, is not communicated in ways that conform to or utilize the terminology or conceptual frameworks that shape global debates or scientific dialogue. Furthermore, their perceptions are not supported by formalized data collection or monitoring systems. As a result, it is impossible to either substantiate or disprove such impressions. These impressions, however, shape behavior at local levels. As a result it is important to understand climate change and variability from the lens of local communities.

The above common impressions in village communities contrast with emerging global knowledge. Rather than the broad baseline changes in climate projected by global simulations, they point toward specific changes in local conditions. This is probably a "natural" consequence emerging as people try to relate to broad messages of change emerging from global work on climate change to the local context in which they live. The broad message of change has no meaning for them unless it is related to the much more tangible factors (wind directions, storms, water availability, etc…) with which they live. Many of the observations at local levels may or may not actually have anything to do with larger scale changes in climate systems. Saline intrusion in coastal areas, for example, may be related to upstream water diversions or groundwater extraction rather than climate change. Similarly, given the inherent limitations of people's memory and the absence of basic conceptual distinctions between weather and climate in local languages, observed changes in wind, precipitation and temperature patterns could simply reflect cyclic natural sources of variability in weather and local climate systems rather than larger anthropogenically induced changes.

Despite the contrast between local experiences and global research on climate change, both echo a common theme – change is occurring but its nature and direction, particularly at local levels, have many unknown elements. Uncertainty and variability are increasing and with that, the reliability of both formal and local sources of knowledge is changing. This information construction contrasts with common demands for information. Whether at policy or local levels, the demand is generally for certainty. People would like to know with certainty what the weather and climate will be tomorrow, next week and next year. Change processes, however, suggest increased uncertainty particularly with regard to the specific conditions encountered at any given time, rather than regional or globally aggregated conditions. The contrast between the type of information "desired" and the types it is possible to produce creates a major communication challenge. As outlined in the following section, this challenge was addressed through development of shared learning dialogue (SLD) methodologies with local-level users.

Communicating Climate in Local Contexts: The SLD methodology

Given the substantial uncertainty that exists regarding the impacts of climate change at local levels, individuals interviewed under this project often questioned the utility of attempting to communicate information on climate change into local contexts. This perspective misses a critical point. Individuals and communities may seek certainty but perhaps the greatest skill required for adapting to climate change relates to the development of systems for responding to patterns of change that are inherently unpredictable. Individuals, households and communities are already responding to change and uncertainty by diversifying livelihoods, shifting away from activities (such as coastal agriculture) as those become less viable and relying on sources of knowledge that provide at least some degree of advance information on weather conditions. Bringing information on climate change into local communities, translating that information into formats that can be used and understood at that level and integrating it with local knowledge, could both support adaptation at local levels and serve as a critical ingredient informing strategies at a global level for responding to climate change. The development of integrated local-global perspectives on climate change could, on a practical level, help to identify points of entry for supporting existing and emergent autonomous adaptive responses. The shared learning dialogue process outlined below and the courses of action it helped to identify for adapting to climate change in our case areas strongly suggest this is the case.

The SLD process

What are "shared learning dialogues"? They are, in essence, iterative small group discussions with local actors in communities, government agencies, NGOs and sector specific organizations that are designed to bring together available information on climate change with local knowledge and perceptions. Shared learning dialogues can serve as one catalytic component underpinning a larger iterative learning process such as that shown in the accompanying diagram.

In our case areas, an initial series of SLDs was used to integrate global climate information and local experience in a way that could be used to identify strategies for adapting to climate change and ultimately to plan and begin implementation. It was, however, recognized as unrealistic to expect that comprehensive solutions for adapting to climate change would emerge from the initial research and strategy identification process. Many strategies, particularly the most innovative, are likely to be experimental. Furthermore, scientific information on climate change is evolving rapidly. This will also be the case with respect to experience on the viability and relative success of different implementation approaches. As a result, SLDs need to support iterative processes of planning, acting, monitoring and reflecting that form the essential foundations for any longer learning process. At the time of writing, SLDs have been used to in all case areas to support strategy identification and the development of an initial set of pilot implementation activities (discussed further below). The longer-term learning process is, however, still in its initial stages.

Core elements in the SLD process used in our case areas focused on:

1. **Openness:** Actors in the external organization approached the SLD process with an open mind and the willingness to absorb and learn from as well as communicate information to local counterparts.

2. **Preparation:** the external organization hosting the SLD came prepared with as much information as possible on the implications of climate change for the area concerned. This information was presented in ways, whether through local language material, pictures, maps, diagrams, models or (as outlined in the accompanying box), radio dramas that could be understood by the local populations.

3. **Careful selection of participants:** One of the most important and, in some ways, most complex issues in catalyzing an effective SLD process has to do with the selection of actors. In order to achieve effective interaction and catalyze a learning process, the size of meetings needs to be kept sufficiently small for dialogue to occur. Ideally, meetings should involve no fewer than 4-5 people and no more than 20. Given the limited size, multiple SLDs may need to be held to capture diversity within communities and across geographic and social scales or silos. To achieve this, the external organization carefully evaluated which sets of communities were important to involve and then structured meetings to ensure that occurred. While our SLDs focused heavily on local village communities supplemented, in a few cases by other key regional experts, in other cases, stakeholders from the following types of communities would be important to involve in SLDs:
    a. Neutral or balanced groups of informed actors: Academics, scientists, key civil society organizations, community leaders. Such groups are often important to convene at the very early stages of an SLD process in order to scope out potential areas of vulnerability or adaptation for more detailed evaluation.
    b. Local groups in villages or urban community areas that share common elements of vulnerability to climate change: The poor residing in vulnerable locations, women, etc…;
    c. Key government actors within regions or municipal corporations;
    d. Civil society groups working on development, disaster risk or in other areas where climate change impacts appear particularly critical
    e. Sector specific actors: It is often most effective to have dialogue around an identified problem area (such as urban water supply) with key actors from that sector.

4. **Structuring:** The SLDs were designed in ways that ensured local counterparts have the opportunity to voice their knowledge and perceptions in ways that communicate local knowledge to the external organization. PRA techniques, such as the construction of sketch maps depicting local conditions (flood zones, community characteristics, etc…), were used to enable communication by communities. More sophisticated techniques, such as the preparation of hazard maps or water models, could play a similar role when the community is comfortable with such techniques or has those capacities.

5. **Iteration:** SLDs are most effective when they involve multiple rounds of interaction. In many cases, the implications of both local and global knowledge only become evident over time when groups have had time to absorb and think through the information presented. The iterative nature of the small group meetings is, in many ways, the most important characteristic required for shared learning to occur. In all case areas, iteration – that is holding of sequential meetings to allow groups to absorb information and consider its implications before moving toward planning and action – formed a core part of the strategy.

As discussed in the sections below, the above process, although often difficult, enabled local counterpart organizations and the communities they were working with to identify an initial set of specific courses of action for responding to climate change.

Strategies Identified & Strategies Rejected

Iterative SLDs conducted in all of the case areas led to the identification of strategies for increasing the resilience of communities in ways that respond both to the likely impacts of climate change and the immediate concerns of local populations. As previously noted, many discussions on climate change transited very rapidly to a focus on current weather events. As a result, improvements in early warning and weather prediction were among the most common strategies identified by communities across all areas. Beyond this, however, the types of strategies identified by both communities and local partner organizations evolved substantially over the course of several iterative meetings.

Initially, most communities and the organizations working with them focused on the value of relatively large-scale protective works to protect against flooding and storm events. These types of interventions have been implemented by the government throughout recent history as part of conventional approaches to the management of floods, storms and other extreme weather events. As a result, local communities are familiar with structural interventions and other large-scale works and expect such strategies to form a cornerstone of any attempt to respond to increased climatic variability. Examples of the specific strategies that emerged during initial dialogues are listed below:

1. **Coastal Tamil Nadu:** Construction of sluice gates or tidal regulators across rivers to prevent the intrusion of saline ocean water, improvements in weather information and early warning regarding cyclones;

2. **Coastal Gujarat:** Construction of embankments to protect low-lying areas from flooding during storms, early warning systems to provide advance notice of flash floods along coastal streams;

3. **Eastern Uttar Pradesh:** Repair of existing embankments and construction of new ones to protect against flood, development of surface and groundwater irrigation systems coupled with insurance for drought protection, provision of seasonal weather forecasts for agriculture;

4. **Nepal Tarai:** Improvement in flood relief and rehabilitation (many SLDs were constructed immediately following a major flood event), improvement in early warning systems, bank stabilization on streams.

As both communities and the local partner organizations evaluated the implications of global climate information further, however, many of these strategies began to appear less viable. All of the major structural measures, for example, required precise knowledge regarding the anticipated magnitude and frequency of major flood or storm events. Ensuring embankments wouldn't breach, thus causing more damage, was acknowledged as requiring information on the size and frequency of future storm and flood events. Similarly, in coastal areas it was recognized that, if sea levels and/or storm intensity increases, the installation of tidal regulators would do little to limit the intrusion of saline water inland into agricultural areas. In fact, across most deltaic coastal areas where the gradient of the land does not increase rapidly away from the shore, it was recognized that strategies for "living with" increasing salinity would be essential. As a result, the focus on strategies for responding to floods, sea level rise and storms through the construction of large-scale physical barriers gradually declined as understanding increased.

Another area where the focus shifted as knowledge on the implications of climate change increased was with respect to the role of insurance. Insurance was initially seen by the national partner organizations participating in the study as a potentially major strategy for spreading drought related risks. As the implications of climate change were analyzed, however, it became clear that knowledge regarding future event probabilities is, in most cases, too weak to actually project potential losses and thus to estimate premium requirements. Furthermore, insurance is only effective if loss-causing events are relatively infrequent. If they become regular events that affect large areas, it is impossible to spread risk and the benefits of insurance decline in relation to the costs (The Risk to Resilience StudyTeam 2009). As a result, higher-level organizations involved in the SLDs had to reevaluate the potential role of insurance in assisting communities to adapt to drought. Insurance remained as a potential strategy, particularly when used in conjunction with irrigation, but its relevance as a stand-alone measure for supporting adaptation declined.

Early warning and the improvement of weather information systems remained as a central strategy as SLDs progressed. As communities and the local organizations working with them increasingly appreciated the limits of climate forecasting abilities, it became clear that long-term projections for local areas might have little meaning. In contrast, the ability to predict weather events, whether using local knowledge or through improvement in formal forecasting systems, seemed likely to, at minimum, remain similar to existing capacities. Furthermore, as data collection, modeling and communication systems improve, so could the ability to accurately forecast weather even if longer-term climatic conditions continue to change. Since storms and flood events are projected to increase in frequency and intensity, improved weather forecasting and early warning systems could greatly assist local populations in responding to climate change.

In addition to altering perceptions regarding potential strategies that were identified during initial SLDs, alternative strategies began to emerge. In specific, potential strategies for diversifying livelihoods away from climate vulnerable activities, developing new livelihood activities consistent with anticipated changes and protecting assets, health and lives in ways that should enable communities to "live with" emerging climate conditions became central in the dialogues. Specific strategies that emerged at this phase included:

1. The development of brackish water agricultural and aquacultural systems in coastal areas. Coastal communities in Gujarat, which have always depended on a combination of farming and deep-sea fishing, decided to explore systems for lobster "fattening" (essentially using brackish water pools to bring lobsters up to commercial size). This was seen as a first step toward developing more integrated aquacultural systems. Similarly in Tamil Nadu, local communities decided to explore possibilities for large-scale farming of emus – birds that are well adapted to saline areas and where the meat and eggs have very high value. They also began to explore options for rehabilitating existing brackish water fisheries. In both locations, such activities were seen as a starting point to move away from agricultural systems in coastal areas that depend on large amounts of fresh water.
2. The development of household and community based structures for protecting lives and assets: In the Uttar Pradesh and the Nepal case study areas, for example, communities began to emphasize the construction of points of refuge from floods where assets could be protected and people could access reliable water supplies and sanitation, rather than reliance on embankments. Specific strategies identified included:
    a. Raising the plinth level of houses
    b. Constructing brick houses and other structures such as schools with flat roofs where assets could be stored and people could take refuge during times of flood
    c. Constructing elevated grain banks (loss of grain is a major economic consequence of flooding);
    d. Constructing wells and sanitation facilities that can be accessed from the roof of houses and other large buildings;
    e. Reducing the impact of floods through planting of forest buffers along vulnerable stream areas; and
3. The development of early warning systems to be used for transmitting both formal weather forecasts and information on river flows and precipitation in upstream areas. Specific pilots emerged for using cell phones, village information centres and other institutional/technological combinations as mechanisms for improving the functioning and institutional robustness of early warning systems.

Details on the above strategies are available in other major publications produced by the project including *Working with the Winds of Change* (Moench, M. and A. Dixit [Eds.] 2007), and *Catalyzing Climate and Disaster Resilience* (The Risk to Resilience Study Team 2009). Brief summary reports from each case site have also been produced and are available on line at www.i-s-e-t.org and, at www.climate-transitions.org.

Conclusions

Results of attempts to identify and utilize existing climate information "products" in local areas as a basis for the development of strategies for adapting to climate change highlight the importance of *processes for translating and interpreting knowledge from a combination of local, as well as global sources,* in order for local populations to identify potential courses of action.

Information products that identify the implications of climate change for local areas are extremely limited. This reflects the limited number of attempts that have been undertaken to downscale results from GCM scenarios and the fact that most research is targeted toward scientific and high-level policy audiences. On a more basic level, however, it reflects the nature of emerging scientific information on climate change. This information is inherently regional and, in many cases, points more toward increasing variability and uncertainty in local conditions than toward the emergence of specific conditions in specific areas.

While such information does have great relevance for courses of action at local levels, that relevance depends heavily on the specific characteristics of local areas. In addition, understanding the relevance of that information often requires changes in the mental orientation of users. People seek certainty. Where climate change is concerned, they want to know *what* will happen, *where* and *when*. In many, if not most cases, climate change implies that variability will increase. As a result, rather than planning for specific changes, local areas need to shift toward the development of response strategies that are robust under highly variable and uncertain conditions. Possibly more than improved climate information products *per se*, achieving *this change in mental orientation requires processes* that assist both local and higher-level actors to interpret the implications of climate change in relation to local conditions.

The shared learning dialogue process piloted in case areas across India and Nepal successfully enabled ISET and our partner organizations to work with local communities in identifying a broad range of strategies that should contribute to the resilience of communities as climate changes. Iterative meetings that enable the interpretation and integration of global scientific and local information represent the core feature of this process. Additional information products that illustrate avenues for planning under high levels of climate uncertainty in diverse local contexts would support this type of process but are probably in themselves less important than the process itself.

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Shared Learning and Adaptation to Climate Change

Climate change will impose upon society stresses that are both similar to and very different from those it has faced throughout history. Climate related disasters and similar events are part of the common "hazardscape" humans have always faced. Yet, changes in climate are likely to cause events and processes to converge in ways that are unprecedented at a global scale and beyond the scope of existing experience. Not only are climate related disasters likely to become more frequent, but, as events converge with fundamental shifts in base climatic conditions, recovery to pre-disaster conditions will in many locations, no longer be feasible or desirable. This convergence is likely to severely strain the systems society has developed as a foundation to reduce, respond to, and recover from disasters. Recovery from disaster will become a much more difficult process of transitioning to new livelihoods and socio-economic systems. Reducing the risk of disaster requires not just building the resilience of existing livelihoods to extreme climate events, but also the ability to identify when livelihoods are no longer tenable. In order to successfully reduce risks, a shift in strategies as the only technically, economically and/or socially effective mechanism for reducing vulnerability is warranted because "average" climate conditions have become inherently more variable and uncertain.

Proactive approaches to risk reduction and will enable communities to make wise adaptation choices based on concise and accessible information. Useable climate information depends upon iterative and shared learning between globally/regionally-focused climate scientists, governments, and local communities who have unique insights into local climate conditions frequently not considered by scientists or policy-makers. The complexities highlighted in this series of brochures point toward the importance of not just additional climate information products, but of *processes* for communicating emerging climate information into local contexts and integrating global and local knowledge sources. Each of the studies utilizes a series of shared-learning dialogues (SLDs) designed to bring global information on climate change together with local information and perspectives on hazards and climate-related conditions. SLDs are iterative, small group discussions with local actors in communities, government agencies, NGOs and sector specific organizations that are designed to bring together available information on climate change with local knowledge and perceptions.

The case studies presented here were designed to explore *both* the way climate information products could be used in developing location specific studies *and* the gaps in understanding that exist between local and global knowledge sources and the how that knowledge is used. Perhaps the single most important lesson to be drawn from these studies is the difficulty inherent in communicating different types of knowledge across major cultural, educational and language boundaries. For example, in Hindi, the regional language across much of northern India, there is only a single word *mausum* that applies to both weather and climate. The distinction between short-term weather variations and the longer-term underlying properties of climate simply isn't a part of the cognitive space enabled by the language. As a result, in initial SLDs, communities tended to focus on short-term actions and large-scale protective works to protect against flooding and storm events. Through subsequent rounds of SLDs, understanding began to emerge about the longer-term, uncertain nature of climate change projections and the high degree of climate variability that make certain actions, such as large-scale protective works untenable. Communities then began to propose different adaptive strategies to respond to the challenges of climate change. The evolution of communication and understanding in each situation are documented in each case study.

The studies highlight the iterative nature of the SLD process and how it was adapted to each situation. Some of the cases presented are still in progress and fully illustrate the necessity of repeated engagement through the SLDs and the multiple layers of understanding present between different stakeholders. Other case studies have largely been completed and highlight the actions being taken by communities as a result of the communication of climate information through the SLD process and the projects. Full information about each of the completed case studies is available in the following publications:

- Moench, M. and A. Dixit [Eds.] (2007), *Working with the Winds of Change: Toward Strategies for Responding to the Risks Associated with Climate Change and other Hazards,* ProVention Consortium, ISET-International and ISET-Nepal, Format Printing Press: Kathmandu.

- Moench, M. et al. [Eds.] (2009), *Catalyzing Climate and Disaster Resilience: Processes for Identifying Tangible and Economically Robust Strategies*, ISET-International and ISET-Nepal, Format Printing Press: Kathmandu.

- Additional information is available on the following websites: www.i-s-e-t.org and www.climate-transitions.org

Further information about currently ongoing studies, particularly with regard to the Asian Cities Climate Change Resilience Network (ACCCRN) is available by contacting the authors/institutions listed in each brochure and will, eventually be written up in more detailed formats as the studies progress. General information about the ACCCRN project can be found at the following website:

- http://www.rockfound.org/initiatives/climate/acccrn.shtml

Shared Learning Dialogues: Coastal Tamil Nadu

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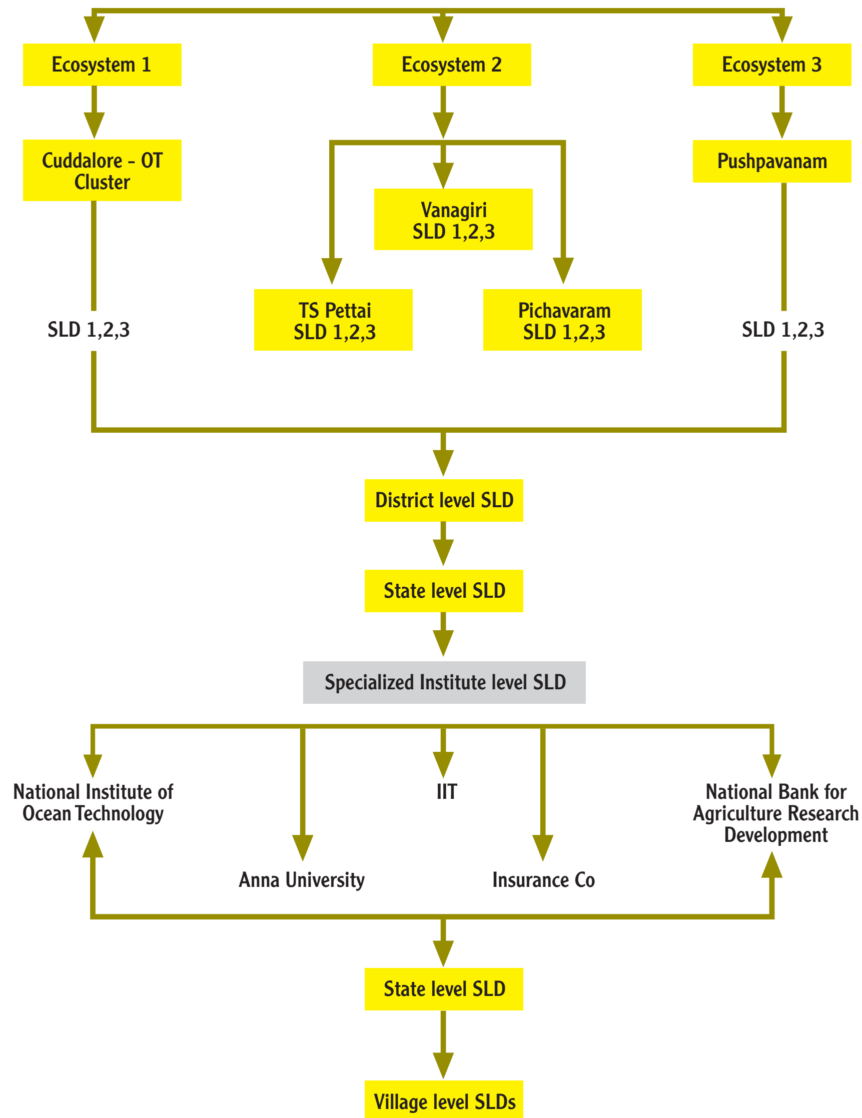
In Tamil Nadu, SLDs were carried out at various levels in an iterative manner as part of the project headed by the Madras Institute for Development Studies (MIDS) after a detailed vulnerability analysis, which is discussed in a separate brochure. First, a series of SLDs at the village level (in the villages of Pichavaram, TS Pettai, Vanagiri, Pushpavanam and the Sonankuppam area of Old Town Cuddalore) were held with various socio-economic groups and the number of participants in each SLD was kept below 20 to ensure better participation. Each SLD yielded specific insights into each group's views on climate hazards and their perceived vulnerabilities and needs. Local knowledge of weather and modes of communicating weather information and early warning were discussed. The SLDs were also used to understand villagers' behaviours during the monsoons, changes in the agricultural seasons, crop patterns and productivity and changes in occupational characteristics. Asset ownership, community-based organisation and coping strategies during times of disaster, and the responses by governments and NGOs were also discussed. Through the iterative SLDs at the village levels, the differentiated natures of vulnerability were uncovered and villagers began to develop strategies for risk reduction.

The insights and questions that emerged at the village level SLDs were communicated and reflected upon at "higher level" SLDs at the district level and state level. Participants at the district level SLDs included the district disaster management officer, officials from the fire department, forest department, insurance officers, local television and mobile telephone operators, and members of self-help groups (SHGs). The state level officers, including the Relief Commissioner, Revenue Secretary, officials from the meteorology department, NGOs, officers from banks and insurance companies, participated in the state-level SLDs to learn from and contribute to the experiences and knowledge gained from lower level SLDs. A separate SLD with specialized officials in Indian Meteorological Department, National Institute of Ocean Technology, IIT-M, and ICMAM was held to share information collected from other SLDs and elicit feedback. Insights and questions from the higher level SLDs were then fed back to a final round of village level SLDs. Discussions at all SLDs at all levels were conducted, recorded and transcribed in Tamil and translated into English for information sharing. Figure 1 displays the SLD process as it was enacted in Tamil Nadu.

These SLDs were supported by an extensive effort to identify specific projections regarding the likely impact of climate change on the region. As in other areas, this review identified very few specific information products aside from those generated at a high level in India's first national communication to the UNFCCC and in the scientific literature. The main conclusions arising from the review, as a result, focused on the likelihood of sea level rise, saline intrusion and increases in the frequency and intensity of coastal storms. All of these are of particular concern because the Tamil Nadu field site is in a low-lying deltaic environment where channels of the Cauvery River enter the ocean. Furthermore, an extensive and complex irrigation network crisscrosses the area, exacerbating flooding, waterlogging and salinisation.

Despite the limited, location-specific information available on the potential impacts of climate change, the SLDs generated substantial discussion and resulted in changes in strategy at the local level. This is particularly true with

The SLD process in Tamil Nadu



local level efforts to control saline intrusion in the Cauvery delta using tailend regulators (TERs). To avoid inundation by brackish and saline water, save freshwater for irrigation, and avoid inundation of land as sea level rises, the agricultural population in the region was demanding construction of a series of tailend regulators close to the sea. These regulators would, however, have implications for fishing since they would effectively eliminate much of the brackish water zone that is a cornerstone of the regional ecosystem. As a result, conflicts exist between fishing and agricultural populations. Furthermore, when the impacts of climate change are considered, major technical concerns exist regarding the ability of tailend regulators to function if sea levels rise and/or storm intensity increases.

Continued interaction with village communities through the SLDs highlighted the potential disadvantages of tailend regulators as a solution to sea-level rise and saline intrusion. As a result, dialogue began to focus on the identification of non-structural measures to strengthen adaptive capacity and the resilience of livelihoods in areas likely to be affected by increases in salinity. In Pichavaram and TS Pettai villages, which are currently among the most affected by

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salinity, a range of ideas emerged that focused on the development of brackish water farming and aquiculture systems. Some ideas, such as expansion of shrimp farming, were identified but rejected (at least for the moment) because of existing environmental concerns. Innovative strategies, such as emu farming were, however, identified and are currently being tested. Emus have potentially major advantages in this region because they are well suited to farming as poultry in salt affected areas, are tolerant of highly variable weather conditions and produce high-value meat and eggs. As a result, introduction of emus could help to diversify farm income away from agriculture and into equally viable but more climate resilient avenues.

In addition to livelihood diversification, other response strategies that emerged during the SLD process included the following:

Improvement of weather information systems: Currently official systems provide limited advanced warning of major weather systems such as tropical cyclones. About 90% of fishermen report that they rely on local knowledge (the types of clouds, the characteristics of ocean waves, temperature, wind speed and the migration of birds) to predict the weather. Improvements in formal weather forecasts were recognized as possible despite climate change. If forecasts from these systems could be compared to the insights generated through local knowledge, hybrid systems might be possible to develop that would be more robust than either traditional knowledge or formal forecasts under changing climatic conditions.

Control of pollution in backwaters and brackish water zones: Currently much of the backwater estuarine zone in the Cauvery delta is heavily polluted by industrial effluent. This has had a major impact on the previously highly productive brackish water fisheries and other ecosystems in the delta. In the Cuddalore area, for example, pollution affects a 2 km zone and has severely affected the livelihoods of small fishermen. Since brackish water areas are likely to grow as a combined consequence of the rises in sea level and increased coastal storms associated with climate change, improving their productivity and management is central to adaptation. As a result, a first step toward adapting to the likely impacts of climate change in the delta may actually require effective control over pollution of this region.

Improvement in credit facilities, particularly during disaster periods for vulnerable communities: At present vulnerable communities (fishermen and farmers) lack access to the low cost credit for meeting subsistence and recovery needs following disasters. As a result, they borrow funds from local money-lenders,The practice is called *thandal* and typically involves small loans at rates of up to 120% per annum.The ability to recover from disasters and to shift away from vulnerable livelihoods is likely to be of increased importance if the frequency or intensity of extreme storms grows as a consequence of climate change. As a result of this, participants in SLDs identified improvements in credit facilities as a critical entry point for supporting adaptation.

Improvement in basic drinking water and sanitation facilities: Increasing salinity and pollution are threatening locally available drinking water sources. As identified in the *Adaptive Capacity and Livelihood Resilience* (Dixit and Moench, 2004) report on adaptation to climatic variability and change, access to basic water supply and sanitation services is, however, essential if populations are to remain in regions as salinity increases with climate change. As a result, improvements in such services represent an avenue for building climate resilience.

Overall, the SLD process in Tamil Nadu resulted in the identification of numerous points of entry where practical activities could be undertaken that, despite the limited available information on the location-specific impacts of climate change, clearly support adaptation. Numerous interventions and disaster risk reduction strategies were discussed during the SLDs and a few were selected for pilot implementation during the course of the project. More information on the emu farming intervention and other piloted interventions are available in the *Adaptation in Practice* brochures on Tamil Nadu, by contacting S. Janakarajan or in the report *Working with the Winds of Change: Toward Strategies for Responding to the Risks Associated with Climate Change and other Hazards.*

Shared Learning Processes for Building a Climate-resilient Indore city, India

By ISET and TARU

Background

It is common knowledge that a large proportion of the Asian population will start living in urban centres by 2050. Increasing urbanisation and economic growth across the region brings an increased risk to climate change along with it. This enhanced risk is due to large urban populations, their enterprises, and that much of urban buildings and lifeline infrastructure are highly vulnerable to climate. In the context of urban areas, it would be safe to claim that climate change shares the stage with several other competing problems, and is interrelated or inter-linked with many of them. Poverty and growth of urban slums are part of the many such problems that modern cities face that will be exacerbated (or face increasing complexity) by climate change impacts.

The urban landscape, in contrast to the rural one, is quite diversified. There are complex inter-linkages and inter-dependencies that need to be explored, assessed and understood. In order to understand the impacts of climate change (on) and (the resulting) vulnerabilities of various facets/sections/groups of an urban area; there is a need to assess these inter-linkages from social, economic, environmental and institutional lenses.

Shared Learning Dialogues (SLD), developed by ISET, are one of the participatory techniques that have been extensively used in the Asian Cities Climate Change Resilience Network (ACCCRN) project for developing an understanding of vulnerability in urban areas. These dialogues also bring understanding to the inter-linkages/ dependence between various sectors and groups in the project cities. As the name implies, the core objective of the SLD process is shared learning – that is, to catalyze a process that enables different groups of actors to bring together knowledge from different sources and jointly develop new insights from that knowledge. In the project cities' context, this translates into understanding the spatial, temporal, socio-economic and thematic (water, energy, etc.) vulnerability factors and to identify adaptation options. The SLD process is (and will be) further augmented and enriched by vulnerability studies (questionnaire-based surveys of different sectors/groups), focused group discussions with various interest groups, GIS enabled spatial vulnerability analysis (for details refer to the brief GIS Enabled Urban Risk and vulnerability Analysis: Indore and Surat for the ACCCRN Project) and specialised sectoral studies. The core of the SLD, however, remains a consultation process that is key to getting a quick grasp of issues and helps build views on vulnerability issues and adaptation options.

The City context

Indore is the most populated city in the central Indian state of Madhya Pradesh located near the drainage divide between the Chambal and Narmada Rivers at an altitude of about 550 m above mean seal level (msl). It is an important city in the western part of India with a population of 1.83 million in 2001, which is expected to grow to about 3.3 million by 2030. This city is essentially a trading centre, on account of its strategic location, serving as a hub for trade and commerce to the entirety of western India. Indore is located in the Deccan volcanic region with black cotton soil. The city lies in the Khan River Basin on flat terrain. The annual rainfall in the region is about 800 mm. The summer temperatures often exceed 45°C.

The city is essentially radial, with the highest density in the Central Business District (CBD), and gradually reducing towards the periphery. Indore is a young city, with over 55% of its population comprised of youth. The slum population is more than one third of the city population.

The city of Indore suffers both from water scarcity and water quality problems (the region was declared drought hit in December 2008). The main source of water for the city is a pipeline from the Narmada River (about 75 km from the city). The other sources of water are the Fateh Sagar Dam and the Bilawali Tank. Even with the extraction of groundwater, water supply in the city is limited to 216 million litres per day (MLD). The Narmada Phase 3 project, likely to be completed by 2009, is expected to increase the water supply to the city to about 385 MLD. Whether this project will be able to close the demand gap is subject to debate. There have been studies indicating that 70% of the tube wells in Indore are contaminated by sewage or industrial pollutants. There are two sewage treatment plants with a total capacity of 90 MLD, which is grossly insufficient for a city of this size.

The drainage in Indore city is also not in a good condition- 80% of the roads in the city do not have roadside drainage. The open *nullahs* (drains) have been converted into closed drains, thus reducing their carrying capacity. Indore experienced a local inundation in 2006, in which some deaths were reported.

Climate Change Impacts on Indore

Global climate models indicate a potential increase in precipitation on the order of 200 to 400 mm, increased variability and an increase in extreme precipitation events for this region. With the city population growing at a rate of nearly 4.6 percent per annum, any increase in rainfall will be offset by the increased demand for water.
Summer temperatures are expected to increase by about 1.5 to 2°C by 2070, which will be over the current temperature peaks of 45°C in the pre-monsoon season. The increase in rainfall and extreme rainfall events, in combination with inadequate drainage and high population growth, may worsen the pluvial floods.

The SLD process

The SLD process in Indore has had three rounds of consultations at different levels to date. The first round of SLDs consisted of one-on-one discussions conducted with various city actors. Sharing was done mainly on the city problems and issues, as well as, the project objectives and activities. Most of the persons that the team met with, shared their concerns regarding water, sanitation and solid waste management issues in the city. The main issues brought forward during these consultations were as follows:

a. Water scarcity is THE major problem in Indore and is felt by all sectors/end-users. Drinking/potable water availability is a major challenge for the entire city. The city-wide water supply is intermittent (less than one hour every alternate day) and acute water shortages during summers (supply reportedly less than 80 lpcd) are experienced.
b. Sewage pipelines and proper evacuation of sewage is almost non-existent in the city, with a drainage system of almost 70 years old and the majority of slums without any drainage system.
c. There are several slum areas in Indore ~ 600+. Only about 40% of the slums are in slightly better condition with some sanitation and/or water taps; the main livelihood in these slum clusters is unskilled labour
d. The health facilities available in most of the slums are very poor and the people end up paying much more for private health care.
e. Road transportation and public transport systems are also in poor condition.
f. Soyabeans (solvent plants for processing), cotton (power looms) and pharmaceuticals are the three main industries in addition to several motor parts ancillary units.

The second round of consultations/interactions were conducted with specific stakeholder groups – city NGOs, communities (Slums and Residents Welfare Associations), industry groups, as well as institutions and urban local bodies (Indore Municipal Corporation-IMC and Indore Development Authority-IDA). This round of consultations focused on taking the discussions further based upon the preliminary findings from the earlier round of SLDs (city specific issues) and learning more about the causes, context, spatial and social dimensions of these issues. The insights gained were as follows:

a. The city is growing rapidly due to the 'push' and 'pull' migration – mostly labourers and students. The hinterland is predominantly agricultural with no other source of livelihood and Indore is developing as an industrial, commercial and educational hub in the region.
b. Water scarcity is likely to continue or worsen due to increasing demand and high energy costs combined with affordability issues. Inequitable distribution of water and leakages (and thefts) due to worn out pipes (approx. 35-40%) contribute to this shortage.
c. Several slum clusters (and even middle income group localities) depend upon tankers and private borewells and pay much more for water than other households. Water tankers are usually deployed during the months of April, May, and June.
d. Rainfall has reduced over the past few years. Rainwater harvesting and groundwater recharge is not being implemented seriously in the city. While the IMC is confident that there will be no water shortage, at least for some years after completion of the Narmada Phase 3 project, the other stakeholders remain skeptical. This skepticism is due to a variety of factors like the time lag between actual supply augmentation and an increase in demand during that period.
e. Groundwater is being extracted in an ad hoc manner – the water table has declined to 500 ft below the surface and most of the tube wells become dry from January until the onset of the monsoon season (there are about 23,000 registered tube wells in the city while approximately a similar number of tube wells are unregistered!). There have been reports of excessive fluoride content in groundwater.
f. The sewerage system is limited to the old part of the city and the existing drains are very old. The biggest problem is fecal contamination of drinking water (several parts of the water distribution system are very old and the water pipes are often laid below the drainage pipes).
g. While many households have septic tanks, open defecation is common – especially in slum areas. Solid waste management is another major issue in the city as was evident both by personal observations and discussions with stakeholders.
h. The city lies in the black cotton soil area, which has low infiltration capacity. The impervious surface in the city has been increasing steadily, mainly on account of an increase in road surfaces and hard paving. Waterlogging is very common. Road levels are often higher than the plinth level of the buildings in many parts of the city, causing floodwaters and sewage to enter buildings.
i. The increase in rainfall and extreme rainfall events can worsen the situation. With large sections of low-income households living along the drainage lines, the vulnerability of these settlements is likely to remain high. The two lakes, located upstream of the city, have an increased risk of breaching and the resulting floods due to extreme precipitation events.
j. Water scarcity, combined with extreme temperatures can increase the stress on the city population, especially during summer months – both in terms of access to clean drinking water and thermal discomfort.
k. Power availability has not yet been a problem area and is available on demand (connections are provided). Energy efficiency (both in public and private sector) is not high on the agenda. The Municipal Corporation of Indore has recently undertaken a project to convert all street lights to CFLs. Given the kind of growth the city is witnessing, there is a need for creating awareness on issues like energy efficiency in small and medium industries (SMEs) and green buildings.

The third round of SLDs were conducted with a smaller group of key persons identified as the City Advisory Committee (CAC). This round focused upon the specific steps and action items related to vulnerability studies in the city. The main outputs from this round were the formation of sub-groups for various sectors/themes and identification of sectoral studies to be undertaken in the cities.

The consultation process undertaken in Indore is shown in the matrix below:

From the above matrix, it is clear that the process of engagement with city stakeholders proceeded in a pre-determined manner, wherein the previous level of engagement and the outputs were taken as inputs for the next level of engagement. In Indore city, the consultation process was also paved with challenges. There are conflicting voices and

Level of SLD Consultation	Key persons/groups	Key outputs	Time period
First level (1-on-1)	ADB Project director, NGO heads, some concerned citizens	Major issues and problems faced by citizens in the city	Dec 2008 – Jan 2009
Second level (specific groups)	IMC, Water Supply Department, IDA, Hotels, Educational Institutions, Industry Associations, Pvt Tankers Association, Community Associations	Deeper understanding of the issues identified during the first rounds and identification of key persons for the inclusion as members of City Advisory Committee	Feb-March 2009
Third level (City Advisory Committee)	Key persons identified for their interest in the project	Sub groups for specific sectors formed, sectoral studies identified	March and July 2009

views on almost every issue and there is a lack of collective-action spirit. One of the glaring examples is that development in Indore has been occuring for the last 17 years without an effective master plan due to litigations. The SLD process however, through different stages, provided space to divergent views and actors. This process of gradual advancement in engagement levels helped to build trust and confidence within the city actors. The IMC was enthused to take on a leadership role in identifying key persons for CAC and to convene the meetings. The CAC now includes members from IMC, IDA, NGOs, prominent citizens, Industry Association representatives, etc.

Furthermore, learning during the SLDs also provided key inputs to the process of vulnerability assessment of households, communities and other sectors (developing questionnaires for surveys, prospective sectoral studies, etc.).

Ways forward

Water scarcity, lack of sewerage/drains and solid waste management are the major current issues for Indore. Even though the proposed Narmada Phase 3 project is expected to improve water availability across the city, high energy inputs and costs of water are likely to be continuing issues in this city.

After three rounds of consultations in the city, the CAC is now almost ready to take on the role of a more informed and enthusiastic partner of the project. Sub-groups were formed during the last SLD conducted and sectoral studies have been identified. The city mayor has been nominated as the patron of this body and a team of three persons (from IMC, IDA and Industry Association) has been identified to take on the lead role in moving this process forward. Thus, the project has buy-in from the key urban local bodies and a major private body (industry) from within the city. The CAC will be providing guidance on the sectoral studies and in their next meeting, will also decide upon the pilot project(s) that could be implemented in the city under this project.

Later on in the project, the CAC will develop the city resilience plans, action points and proposals (with facilitation from ISET and TARU) once the results from the surveys, sectoral studies and pilot implementation projects are obtained.

Shared Learning Dialogues and Identified Response Strategies in Gujarat, India

Nafisa Barot - Utthan, Sara Ahmed - IDRC and Eva Saroch - ISET

A series of Shared Learning Dialogues (SLDs) at the village, district and state level were held at different phases of the NOAA project. At the state level, a one-day SLD on "Climate Resilient Development and Adaptation" was held at the Ahmedabad Management Association (AMA) in June of 2007. A heterogeneous group comprising civil society, academician and government experts participated in this SLD. In the context of communication activities, it was agreed that radio, local TV channels, etc. must be used to alert the coastal communities in case of calamities. Secondly, by using local NGOs' community network organizations, such as the Indian Space Research Organization (ISRO), climatic information can be disseminated. Thirdly, it is important to strengthen the communication dissemination system and make use of the Right to Information Act (RTI) to get information at the community level. Lastly, there is a need to develop linkages with audio-visual media to build awareness about the issues and early warning systems for the fishermen.

At the village level a series of shared learning dialogues were conducted in the villages of Katpar, Sartanpar and Tarasara in the state of Gujarat, field sites where Utthan has been supporting pilot projects to increase resilience to climate change. The focus of these SLDs was to capture the diverse perceptions of the communities in these villages about climate variability and change. The process included carrying out resource mapping of the entire village, vulnerability mapping in the context of floods and cyclones through focus group discussions, and Participatory Rural Appraisal (PRA). Additionally, the process included performing situational analysis, as well as, in order to uncover possible adaptation alternatives. These processes were carried out at different levels, including the government and other agencies.

To facilitate these SLDs, Utthan conducted an extensive, but unsuccessful, search for location specific information on the likely impacts of climate change. Given the absence of such information products, they reviewed existing scientific literature with relevance to the region and prepared materials to support the SLDs. These materials conveyed very basic messages concerning climate change, including: (1) the potential for changes in sea level; (2) the likelihood of increases in climate variability; and (3) the potential for increases in extreme climate events such as floods and coastal storms. This was done mainly through collecting data from websites, from various government departments (which was very time consuming), through personal interaction, and by carrying out a historical timeline of various disasters such as droughts, floods, cyclones. These hazards are related to climate variability and to change in the overall local ecosystem. The major challenge was to decipher the differences between manmade vulnerability and natural hazards.

Climate products available at the national and state level included climate maps and rainfall data are used at various levels for different purposes. Of such products, monsoon maps, annual rainfall maps, average temperature maps, monographs of river basins, annual snowfall data, and marine climatological atlases were all available at the national level. Materials such as annual, daily and average rainfall, as well as humidity and temperature are available at the state level and possibly smaller jurisdictional levels. Additionally, records of daily temperature, wind speed, wind velocity and wind direction are available to NGO's and communities from various sources like print, visual media and web portals. There are flood zone maps, drought zone maps and cyclone zone maps of Gujarat. The Indian Meteorological Department's (IMD) area cyclone warning centers at Chennai, Calcutta and Mumbai and the cyclone warning centers at Ahmedabad, Bhuvneshvar and Vishakhapattinam (Vizag) issue cyclone warnings, bulletins for fishermen and bulletins for ships at sea. There is also short range forecasting made available by IMD that provide predictions of weather conditions two days in advance.

Climate and weather information available at the district level is collected/gathered mainly by government agencies/ departments in the Bhavnagar district. The collection of weather information is done by the Water Resources Investigation Division, the Gujarat Maritime Board at the ports, the Fisheries Department and the Agricultural Universities Research Station. The district disaster management cell and the district administration, along with the Taluka and village level administration then communicate this information down to the community level. Apart from this existing arrangement, both early warning and less urgent climate/weather reporting is done via media-print and electronically from both within and outside of the district. Within the district, no telecom services providers provide the climate/weather alerts through the value added services. The NGOs in the district work mainly on disaster rehabilitation and recovery phases. They do not directly give/gather/use the climate/weather information and are not as actively focused on disaster mitigation or risk reduction. The People's Learning Centre-Coastal Livelihood and Disaster Mitigation has now started providing the climate and weather information (temperature, rainfall, pressure, humidity) at the information centers located at five locations within the Bhavnagar district. Communities can access the weather information through the local weather station in their villages. There are two weather stations in Tarasara and Sartanpar and people can easily access those weather stations.

During the SLDs, local participants highlighted three aspects of climate where they believe changes are occurring: (1) increases in the number of rainy days and rainfall intensity; (2) extension of the length of the winter cold season[1] ; and (3) higher levels of variability between seasons, e.g. this year 60% of Gujarat has received less then 50% of rainfall. Such changes were consistent with some regional projections of climate change, excepting the lengthening of the winter cold season, identified by Utthan but were recognized as not necessarily being a consequence of climate change processes. Villagers did not observe any perceptible change in sea level over the past 80 years but recognized that it could occur.

Another SLD with youth groups from selected disaster sites in the coastal areas of the Bhavnagar and Amreli districts were organized. The discussion covered the following key points:

- To understand climatic variability and perceived changes in the region during last 30-40 years
- To initiate discussions and increase awareness on climatic change and its impacts on youth
- To increase the involvement of youth in addressing the climate change related impacts in the area

Outcome of Shared Learning Dialogue with Youth Groups

The following synopsis summarises feedback received during the youth-focused SLDs. According the youths (based on knowledge passed down from previous generations), 40 years ago the coastal area was rich with trees and greenery and high-quality freshwater was easily available. In the last 25 years, the availability of high-quality freshwater has deteriorated due to overdraft of groundwater and increased salinity, making it more and more difficult to get water for drinking and irrigation. There have changes in the agriculture patterns in the coastal area, as well. Food crops have been replaced by high water intensive crops like ground nuts, onion and cotton. Mango and guava trees have been replaced by chickoo fruit trees. New crop diseases have also emerged. In the last 7 years, slow changes in housing

[1] The perception of a lengthening in the cold season highlights the difficulty in communicating weather and climate information in Hindi. There is only one word *mausam* in Hindi to describe both weather and climate, that is to say, there is no distinguishment between the two within the cultural concept-space. During the 2007-2008 winter cold season, the cold spell lasted longer than to what the communities are accustomed. Actual climate records for the region, and much of India, indicate a shortening of the cold season and fewer cold spells over the past few decades. However, due to different conceptions of weather and climate, a few recent incidents are perceived as indicating the winter season is becoming longer. Thus, in their mental mapping, this recent incident is indicative of "climate change", even though it such an individual event cannot be constituted as climate change within the Western mental map.

construction patterns can be seen - those who are financially capable are constructing their houses to be more resilient to natural hazards. People have replaced the earlier grass roofs with tiles. More recently, slabs are being used for roofs and improved construction technology is increasing resiliency to natural climate hazards like floods and cyclones.

Additionally, the duration of the winter season has become longer, according to the youth. Normally, after Uttarayan (14th January) it becomes less cold, but last year itself (2007-08) the winter season extended until 14th February (refer to the footnote).The duration of the monsoons has increased in the last few years, as well as an increase in the average rainfall, leading to alarming flood situations in this area (and other low-lying areas). Lastly, the frequency and intensity of floods and cyclones have increased in the last 5 years. Again, the aforementioned concepts are based on the youths' perception and/or witnessing of changes/adaptations seen or made within the communities in past years or based on stories from family members.

Climate Change Forums, Discussion in Coastal Area-People's Learning Centre:

The People's Learning Centre displays local climate and daily weather information for the district at its three information centres within the district. Such weather/climate information is also displayed at five other information centres located outside of the district in Bhavnagar and Amreli. Ongoing work in these areas is planned, such as the discussion, communication and knowledge exploration about climate change at various forums (i.e. schools, adult education programs, Gramsabhas and Sarpanch Sammelans, etc.). Utthan also plans on discussing the impacts of climate change at higher secondary schools for opinion formation of the younger generation. Better ways of disseminating climate information to communities are being explored. Effective forums like Gramsabhas and Mahila/ Sarpanch Sammelans could be used to spread awareness about climate variability, change and building resiliency. Information Education Communication (IEC) materials depicting local climatic impacts/conditions in vernacular languages are currently being developed.

Lobster fattening: Utthan has initiated a small, but viable, lobster fattening programme in a couple of coastal Gujarati villages with technical support from the Coastal Salinity Prevention Cell (CSPC).This pilot intervention is a part of community-based, coastal initiatives to strengthen local sources of employment, particularly through Self Help Groups (SHGs) and to demonstrate aquaculture as a potentially significant income generating activity in this region.The coastal belt of Gujarat is suitable for spiny and rock lobsters, commonly found along rocky shores. Under the programme, demonstrations on lobster fattening were conducted at two selected sites: Akthariya in Mahuva taluka, Bhavnagar district and Chanch-Bawadia in Rajula, Amreli dstrict. Prior to Utthan's intervention, the majority of lobsters caught in this area used to fetch a lower price in the market, as they weighed around 100 grams only.With the fattening programme, now the lobster weighs around 150 gm and the value of the live lobster can command a good price in the market.This programme has so far directly benefited 48 families belonging to two SHGs (70% of these come from BPL households) within these two clusters, and has generated employment for 120 people-days in a year. Following this pilot demonstration, the National Centre for Sustainable Aquaculture (NACSA), as well as the Marine Products Export Development Authority (MPEDA), has shown interest in replicating and upscaling this activity to other coastal villages. Efforts are underway also to engage women's Self Help Groups (SHGs) in rope making by linking them up with Area Level Federations (of SHGs) for inputs and marketing on products (Ahmed, et al 2008).

Identified response strategies

Drawing on a combination of local perceptions and broad insights from the scientific literature as summarized by Utthan, strategies for coping with climate change were identified. These included:

- Institutionalising gender and people-centric mechanisms that would proactively respond to the needs of the communities, especially the most vulnerable.This will enable sensitisation, capacity building, awareness creation, inclusive participation, linkages and implementation of pilots, extract learning and sharing at various levels for policy, behavioral change, etc. Above all, it would develop practices of good governance and ownership that would sustain the process.

- The development of early warning communication systems. These would help to reduce existing storm and flood risks for portions of the community engaged in agriculture and fishing. Improvements in such systems were viewed as particularly important if the occurrence of extreme events increases. In addition to technologies, participants emphasized the need to establish linkages with relevant government officials, particularly the District Collector, Mamtladar, dam site authorities and port authorities. They also emphasized the need to establish effective communication systems in the village so that individuals and households can strengthen their preparedness measures.
- Improvement of sanitation and safe drinking water facilities that can continue to function during extreme events, as well as construction of houses for temporary shelter. Access to shelter, sanitation and drinking water is currently a major problem during storms and floods at present and is likely to be exacerbated as climate change proceeds.
- Livelihood security and development of livelihood activities consistent with sea level rises and increases in salinity ingress due to coastal storms. Although communities did not observe any changes in sea level, salinity ingress in the region is a major concern during storms. As a result, they identified lobster fattening (using cages to bring small lobsters up to the size required for marketing) as a new livelihood activity that could be tested and would be consistent with potential climate change impacts. Community members also suggested placing increased emphasis on the plantation of salt tolerant crop varieties in the coastal saline region as a related strategy. Additionally, this would reduce soil erosion along the riverbanks.

There is a need for strategies to respond to the protection of human life, food security, gender needs, especially in the face of increased climate variability and as yet, unquantifiable climate change. Presently, there are no policies that help communities to recoup losses or livelihood damages caused by cyclones, floods or drought unless and until such an event occurs over a large area. Additionally, the increase in intensity and frequency of rains has had an adverse impact on the agriculture crops. However, the villagers have yet to come up with strategies regarding changing cropping patterns, whether by shifting crop varieties or the timing of planting. The major limitation blocking use of existing climate change information in daily life are as follows:

- People believe in existing impacts of the climate change, but they don't see this to be relevant at a local level (their community), and
- They conceptually understand what the major impacts of climate change are (i.e. sea level rise), but they haven't recognised these types of change in their area or how change might impact their livelihoods and activites.

Given these two perceptions, it is difficult to encourage people to change their behaviours to adopt livelihood diversification and explore other options to increase resiliency. More work needs to be done on education and communication of weather and climate information in order to affect change.

References

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Projecting Climate Change Impacts on Smaller Geographic Scales: Downscaling to the Rohini Basin, Nepal

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Why Climate Downscaling?

In order to understand the manner in which floods, droughts, storms or other weather related disasters may change as climatic conditions evolve, analysts are limited by the current state of scientific understanding, the computational requirements of general and regional circulation models (GCMs and RCMs), and the length and quality of observational data. Projections, such as those synthesized by the Intergovermental Pannel on Climate Change (IPCC) in its reports are very general. They discuss trends and broad patterns of global and continental change. They also identify geographic regions, such as the Himalayas, where available information points toward the potential for substantial change but limited scientific consensus exists regarding the magnitudes of change and, as a result, uncertainty in projections is high. Moving beyond general projections requires familiarity with climate science, which is evolving rapidly, and the ability to make projections for the specific region and hazard of concern. This later element, the downscaling of global model results to produce specific projections for specific locations, is the main step required for developing adaptation strategies regarding future climate risks.

The majority of climate change projections are made using general circulation models (GCMs) for a global scale, with a geographic resolution of 100-200km. The resolution of GMCs is too broad to be of use in developing disaster risk reduction and adaptation measures, at smaller scales such as river basins. The ability of cost benefit analysis (CBA) and other techniques to assess the economic viability of DRR investments, or the development of structural interventions such as embankments, requires probabalistic information about the frequency of occurrence and potential magnitude of events such as floods and droughts.

There are two common downscaling techniques used to translate large-scale GCM projections to smaller scales: 1) regional climate models and 2) statistical downscaling models. RCMs are more physically complete as they attempt model physical land-ocean-atmosphere interactions that govern weather and climate, but take enormous computational power and time to run. Statistical downscaling techniques are potentially less accurate as they attempt to establish a statstical relationship between point source weather variables, such as precipitation, and large-scale climate fields such as wind or air pressure at different atmospheric levels. However, statistical methods are conducive to situations in which time is short and computational power limited and can give reliable, first-pass estimates of potential climate change for a small region.

The Risk to Resilience project, funded by NOAA and IDRC, assessed the viability of current DRR investments and investigate their continued relevance under various climate change scenarios for eastern Uttar Pradesh. To do this, we developed a robust statistical downscaling technique for relating large-scale climate information, such as wind or atmospheric pressure, to rainfall patterns in the Rohini Basin. We must caution, however, that while the method presented here can provide key insights into potential climate change impacts in the basin, the projected changes in basin rainfall patterns (timing and amount) exhibit a high degree of uncertainty that remains unresolvable for the near future.

Climate Downscaling Methodology

There is significant disagreement between GCMs about current precipitation patterns for South Asia (Kripalani et al. 2007), which contribute to a high degree of uncertainty and a broad range in projections of current and future precipitation estimates (Christensen et al. 2007). Global temperature projections are fairly robust; most agree that temperatures are increasing and will continue to increase (Christensen et al. 2007). The global precipitation projections, though, vary widely in timing, geographic distribution, amount and variability between all the GCMs. However, the GCMs are able to simulate large-scale climate fields, such as wind, specific humidity and geopotential height (atmospheric pressure) quite well and are generally in agreement (Trigo and Palutikof 2001; Osborn et al. 1999).

We took advantage of the GCM's ability to reliably simulate large-scale climate fields to derive basin-scale rainfall forecasts for the Rohini Basin. The model employed is a non-parametric, stochastic downscaling approach based on the *k*-nearest neighbour (K-NN) algorithm (Yates et al. 2003; Gangopadhyay et al. 2005). We modified the algorithm to forecast monthly precipitation ensembles, based on various climate change scenarios that were then disaggregated to daily precipitation estimates. The steps taken to perform the downscaling are described below:

Step 1: Data Collection

The Rohini Basin straddles the border of Uttar Pradesh (India) and Newalparsi (Nepal) with approximately 70% of the basin lying in India. The basin receives the majority (70-90%, depending on location) of its annual precipitation during the monsoon months of June-September. After some difficulty, daily rainfall data for five weather stations on the Nepali side were acquired with the most complete datasets running from 1976-2006. No information exists about how the data were collected or the steps taken to ensure validity. Unfortunately, due to budgetary constraints, we were not able to purchase data sets for the Indian side of the border. Thus, information on rainfall patterns for the geographic majority of the basin is missing in this study.

After collecting rainfall data, selection of the large-scale climate fields commenced. Selection of large-scale climate fields is governed by two sets of assumptions that determine the physical relationship between the local variable (rainfall) and the large-scale variables. The first set is based on the necessary atmospheric conditions that allow for convective activity, upon which most of the Rohini's monsoon rainfall is based:

1) changes in air pressure that lead to atmospheric instability (measured through geopotential height)
2) moist air (measured through specific humidity)
3) warm air (measured through air temperature)
4) a transport mechanism to move the warm, moist air (measured through winds)

The second set of conditions is governed by their climate change relevance (von Storch et al. 2000):

1) the large-scale climate predictors have a direct physical relationship with the local variable and are realistically modelled by the GCMs
2) the physical relationship between the large-scale predictors and the rainfall is expected to remain relevant in the future, regardless of climate change
3) the large-scale climate predictors capture the climate change signal.

We selected the large-scale climate variables – geopotential height, zonal and meridional winds, specific humidity and air temperature, according to the two sets of conditions just outlined. Large-scale variables from the historical period of 1976-2006 were obtained from the NCEP/NCAR Reanalysis datasets (Kalnay et al. 1996). This set of observed climate patterns was gathered to test the ability of the model to replicate past rainfalls. If the model is able to replicate past rainfall well, we have some confidence in the climate change projections.

The second set of large-scale climate variables was gathered from the Canadian Third Generation Coupled Climate Model (CGCM3). This set represents potential climate change scenarios and are used to simulate future rainfalls for the basin. Selection of data from the CGCM3 was done after a literature analysis to determine which GCM is currently best able to replicate key features of the South Asian Monsoon. Kripilani et al. (2007) analyzed the ability of 22 AR4 GCMs (the same the IPCC summarized) to reproduce historic key features of the Indian monsoon and found that only six models performed well. No literature could be found comparing GCM performace over Nepal, so a large assumption was made that the studies of model performace for the all-India monsoon would be representative of Nepal. Out of the six possible GCM candidates Kripilani et al. identified, data from the CGCM3 proved easiest to access.Thus, we chose this model to provide climate change scenarios to drive the rainfall downscaling in our model. Partners involved in this project agreed that we would use the A2 and B1 climate change scenarios.[1] Due to the planning timescales critical to DRR interventions we only utilized climate change scenarios for the years 2007-2050.

Step 2: Final selection of climate variables
The physical relationships between the large-scale climate indices and the basin rainfall can be established using correlation analysis. We performed correlation analysis between each month's total rainfall (1976-2006) with various large-scale climate indices from the NCEP dataset.The correlations were tested for significance and the climate index that had the highest correlation with the month's rainfall was identified and used to form the predictor set.

Step 3:Testing the model over the historic period 1976-2006
During the testing phase, the model is run in drop-one, cross-validation mode.This means that the year for which the model is trying to predict rainfall is dropped from the rainfall and large-scale climate datasets. For instance, if we are trying to project the rainfall for May 1980, the rainfall and large-scale climate indices of May 1980 are dropped from the datasets.The model then makes the rainfall prediction using the remainder of the data.

The model works by finding an anaolgue between the rainfall/large-scale climate variables of the month (say May) and year (1980) to be projected and all data for that same month for the whole historic period (all Mays 1976-2006, except May 1980) minus the year to project.The years with the most similar large-scale climate features to May 1980 are retained (the K-NN years) and resampled to make projections.The resampling process generates multiple rainfall values (ensembles) to give a range of possible rainfalls under those particular historic large-scale climate conditions.

Step 4:Verifying the model over the testing period 1976-2006
Each ensemble forecast is equally probable for the period 2007-2050.We won't know until the future is history which forecast the most accurate. *We can only test the model's accuracy, and whether or not the large-scale climate variables choosen capture the majority of physical processes governing rainfall in the Rohini Basin, by seeing how well the model could hindcast rainfalls for 1976-2006.* We employed several comparison techniques to test the model's performance.

Step 5: Generating future rainfall conditioned on climate change scenarios A2 and B1
The generation of future rainfall for the Rohini Basin is based on comparing the projected large-scale climate variables from CGCM3 with the historically observered large-scale climate variables from NCEP. Say we are trying to predict rainfall for May 2020.The large-scale climate indices of May 2020 calculated from CGCM3 are compared with the large-scale climate variables of all Mays 1976-2006 calculated from NCEP.The rainfall amounts of the K-NN from the historical period are resampled to produce the mean rainfall projections for May 2020.The residuals are then resampled and added (bootstrapped) onto the main projections to generate rainfall ensembles.

Results and Discussion

The model was better able to hindcast rainfall for some months than others for the period 1976-2006, in particular the months of February-May, August, November and December.The model had limited, but still useful, confidence in rainfall hindcasts for June and July.The rainfall hindcasts for January, September and October exhibit little skill.

The ability to hindcast rainfall in certain months over others is largely due to atmospheric conditions and the ability of the selected large-scale variables to capture the atmospheric conditions. January is dry in most years.When rainfall does occur in this month, it is usually due to remenants of depressions that formed over the Mediterranean that transport moisture into Nepal.The timescale of these depressions is on the order of a couple of days, and aren't

[1] For a detailed description of the A2 and B1 climate change scenarios, refer to the IPCC (2000) Special Report on Emission Scenarios.

captured in the monthly timestep of the model. During September and October, the atmospheric conditions that create and sustain the monsoon are falling apart and the atmosphere doesn't stabilize until November.The model cannot capture these rapidly changing atmospheric processes.There is a great deal of uncertainty in the future projections of climate change impacts on rainfall in the Rohini Basin. For the future, the rainfall predictions are shown below:

	IPCC - South Asia			Rohini Basin					
	A1B			B1			A2		
Season	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**
Dec - Feb	-9	5	1	-104	-89	-59	-37	-24	-1
March - May	-2	9	18	-59	-52	-28	-60	-55	-35
June - Aug	4	11	16	-4	1	11	-3	0.5	10
Sept - Nov	8	15	20	-19	-13	-1	-15	-9	2
Annual	**4**	**11**	**15**	**-12**	**-7**	**4**	**-10**	**-6**	**5**

Illustrative comparison of the interquartile IPCC projections for the entire South Asia region (to period 2080-2099) with the downscaling interquartile projections for the Rohini Basin (projections for 2010-2050). Values are in percentage departures from the historic mean (1980-1999 for IPCC; 1976-2006 for Rohini Basin). Thus, a direct comparison should not be made to the values.

Illustrative comparison of the interquartile IPCC projections for the entire South Asia region (to period 2080-2099) with the downscaling interquartile projections for the Rohini Basin (projections for 2010-2050).Values are in percentage departures from the historic mean (1980-1999 for IPCC; 1976-2006 for Rohini Basin).Thus, a direct comparison should not be made to the values.

The median rainfall projections show a significant decrease in rainfall during non-monsoon months and a slight increase in precipitation during the monsoon. However, there is a high degree of variability in projections for all months of the year, indicating that the rainfall can be much higher or lower than the median projections in each month. Without having done the downscaling using output from several GCMs, it is impossible to put bounds on the uncertainty in the Rohini rainfall projections. However, the rainfall projections during non-monsoon months, while low, are consistent with the downward rainfall trends over all of India during non-monsoon months projected by other scientists (Kumar et al. 2006; Gosain et al. 2006). Likewise, other studies are projecting increases in monsoon rainfall, althought the projections in rainfall amounts vary.The most important consistent finding between this study and others is that *variability* in rainfall is projected to increase greatly in all months.

Use of Results from Downscaling

Results from the quantitative climate downscaling exercise are of critical importance for both qualitative and quantitative evaluation of the costs and benefits likely to be generated by different disaster risk management strategies.

First, where qualitative evaluations are concerned, the range of potential rainfall patterns generated through even a relatively limited modeling exercise such as this can be used to give stakeholders a sense of the inherent uncertainty that is hidden in more general synthesis results from gobal scientific activities. Published projections of climate change for India, for example, suggest an overall increase in precipitation of perhaps 5% to 20%. No published climate change literature exists on potential climate change impacts for Nepal. Studies are now underway to downscale climate projections for Nepal and are referred to in the brief *Climate Projections for Nepal.* Results from our Rohini modeling exercise, however, show prominent decreases during some months. Such differences drive home the point that climate projctions for large geographic reiongs may differ greatly from the realities likely to be experienced in specific basins or locations.This "realization" is of fundamental importance for any discussion of specific adaptation response strategies.

Second, techniques for modeling climate change generate ensembles of results. In our case, the limited modeling exercise produced an ensemble of 150 potential rainfall futures. Using statistical techniques to select scenarios that "bracket" conditions in all other scenarios (i.e. that reflect the extremes), we selected only a few of the ensemble members to use in the flood and drought modeling for cost-benefit analysis of risk management interventions. This was necessary due to limitations on computing capacity; running the hydrologic model to estimate flooding for each scenario took two days of computer time. Ideally, however, the entire hydrologic and cost-benefit analysis should have been run using more of the ensemble members. This would have generated a distribution of cost-benefit results for each DRR intervention that could have been used to determine the robustness of returns under the full selection of future scenarios.

Third, as the climate experts emphasize, the *uncertainty* inherent in projections of future climate conditions is very high. This uncertainty is due to a variety of factors, such as, insufficient observation records, incomplete understanding of ocean-land-atmospheric physical processes, rapidly changing human influences on the earth, and the ability to model what we do understand. There is a fundamental difference between risk and uncertainty. When event probabilities can accurately be calculated, risk can be estimated. If, however, probabilities cannot be attached to events, uncertainty is high. The fact that climate projections often contain a high level of uncertainty is a fundamental limitation on probabalistic approaches to cost-benefit analysis of disaster risk management. Where uncertainty is high, probabalistic approaches to cost benefit analyses can only be viewed as a scenario generation process.

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Vulnerability Analysis: Initial Analysis of Gorakhpur City for ACCCRN

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B.K. Singh - GEAG

Gorakhpur is one of the cities participating in the Asian Cities Climate Change Resiliency Network (ACCCRN). The objectives of the ACCCRN program are to:

- Test and demonstrate a range of actions to build climate change resilience in cities
- Build a replicable base of lessons learned, successes and failures
- Assist cities in developing and implementing a climate change resilience building process
- Build the capacity of cities to continue climate change resilience building activities.

The other Indian cities participating in ACCCRN are Surat in the state of Gujurat and Indore, in the state of Madhya Pradesh. The first phases of the project involve understanding the current levels of vulnerability in each of the cities in order to begin moving to resiliency. More information about the ACCCRN program can be found at: http://www.rockfound.org/initiatives/climate/acccrn.shtml or in the ACCCRN brochure.

Gorakhpur is one of the most important cities in the eastern Gangetic basin. The city is the principal urban settlement in the trans-saryu region of eastern Uttar Pradesh State. The cities in this region are smaller and highly influenced by the surrounding rural populations and ways of life. The rural influence is quite dominant in all aspects of city life including, livelihood patterns, housing, fuel, and transportation, among others.

Gorakhpur is the only city in this region having more than 0.5 million in population and has the status of a Municipal Corporation. The 6.22 lakhs* population of the city is spread throughout 136 sq. km (2001 census). With the current rate of population growth, the population of the city is expected to almost double by the year 2025. The city is distributed in 70 urban wards and has 110 slums.

The city is generally low lying and its elevation ranges from 75 to 85 meters above sea level. The northern part is generally higher with slope towards the southern areas. Traditionally, the drainage of the city has been dependent on 103 water bodies located throughout the city area that provided a buffer against excess water by providing infiltration areas. The average temperature of the city is 25.5^{0}C with a high relative humidity.

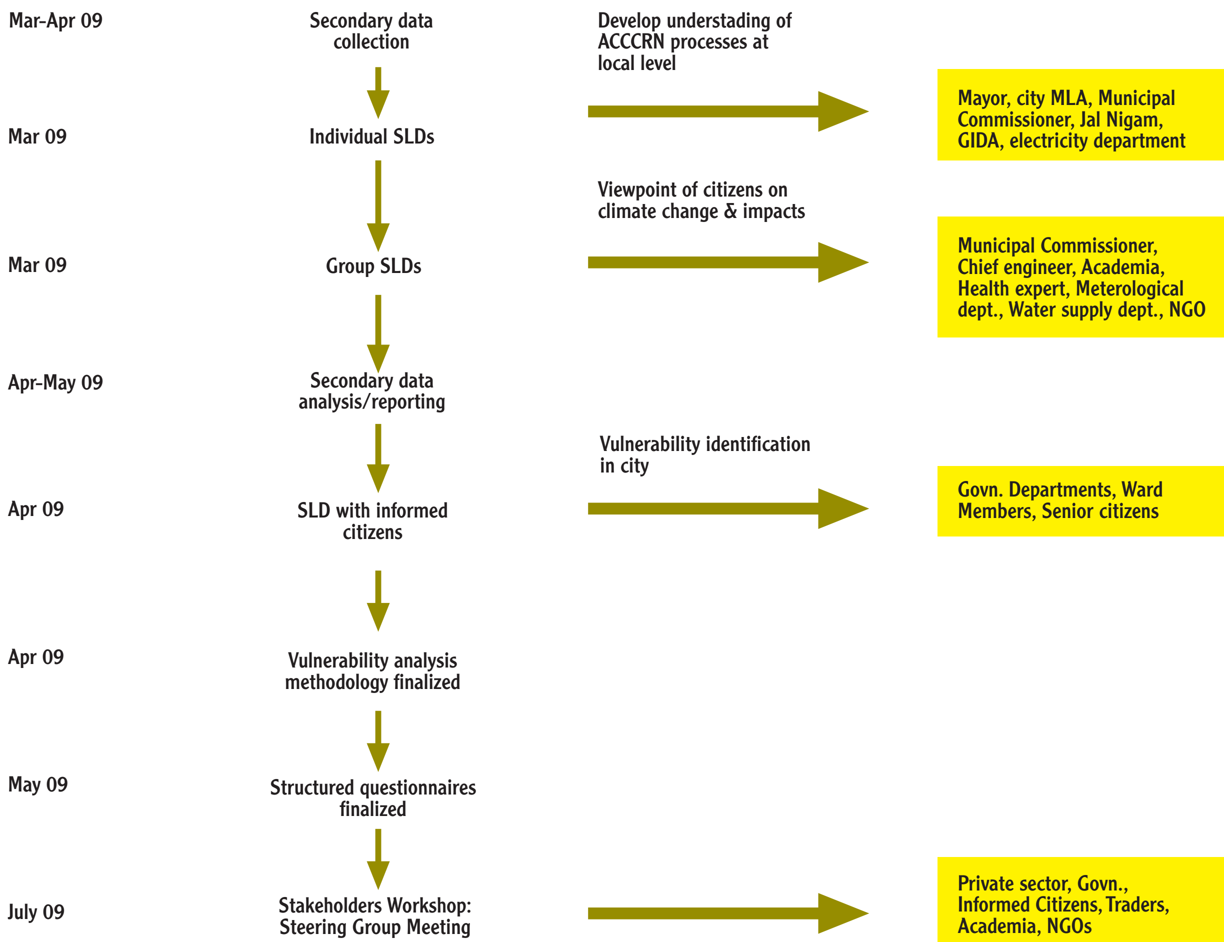
Methodology

A series of shared learning dialogues (SLDs), vulnerability analyses (incorporating a variety of techniques, such as from Participatory Learning Assessments or PLA), secondary data collection and data collection from GEAG's previous work

* 1 lakh is equivalent to 100,000.

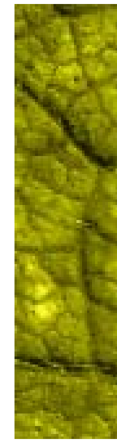
(GEAG 1996; 1998) have been carried out for Gorakhpur to assess the current levels of vulnerability, differentially disproportionate for particular groups such as women or landless labourers, and begin projecting how vulnerability might evolve under variable and little understood climate change impacts for the region. The processes of data collection and risk / vulnerability analysis are presented in following diagrams.

The SLD Process in Gorakhpur



Note: GIDA: Gorakhpur Industrial Development Authority (A government agency set up to encourage industry). MLA: Member of Legislative Assembly (a member of Uttar Pradesh Parliament).

Information and ideas discussed during the SLD processes fed into and informed the vulnerability analysis. The vulnerability analysis included the classification of socio-economic household groups as one method for distinguishing the different factors contributing to vulnerability for each group. Groups were divided into lower, middle and higher income socio-economic classes (SEC in diagram). The steps included in the initial vulnerability analysis of Gorakhpur are displayed in the next diagram.



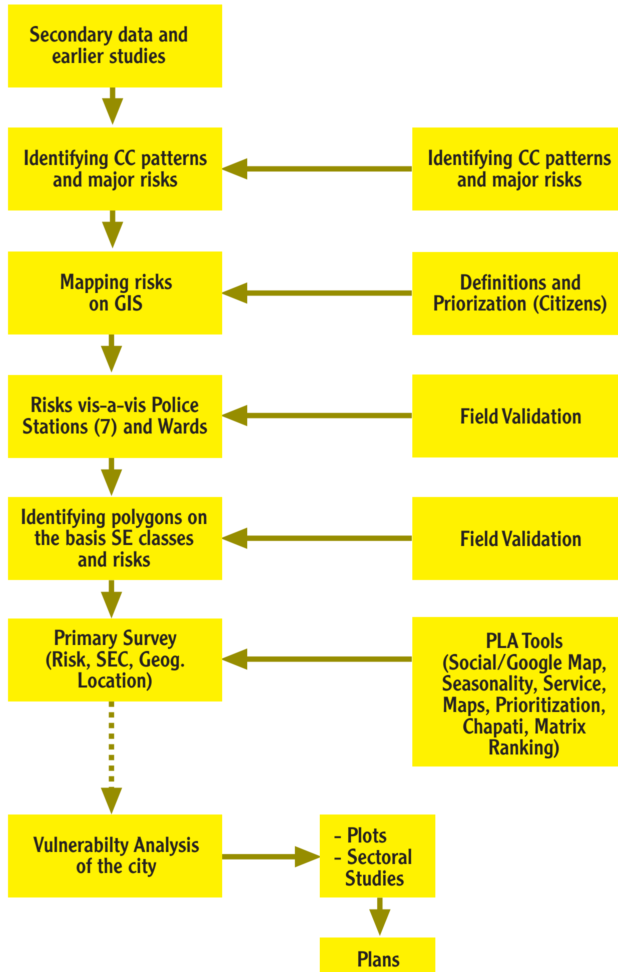
Vulnerability in Gorakhpur City

As emerged from the SLDs, the available secondary data and the vulnerability analyses described above, the following issues were identified as the primary hazard risks in the city that will be aggravated by climate change patterns.These results of the analyses presented here are only initial results. Further iterations and insights will be collected throughout the ACCCRN project duration. It is expected that these processes will enable the city to comprehend its vulnerabilities and lead to a concrete plan of action for the city, which will be able to reduce the projected vulnerabilities of people.

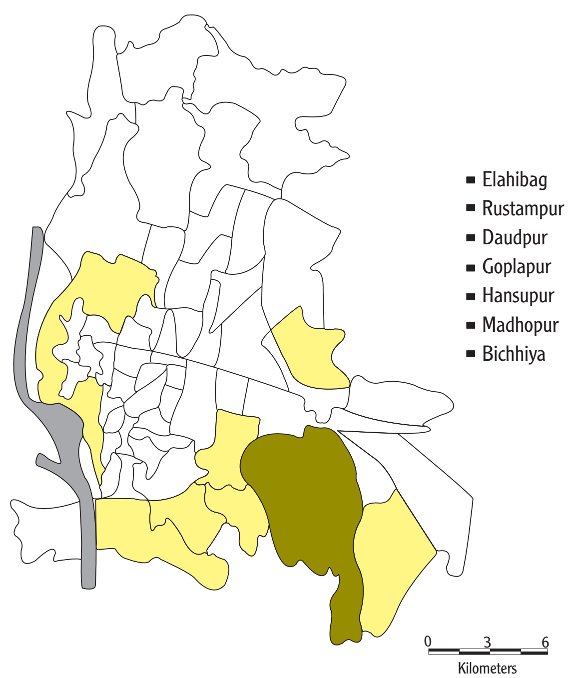
Waterlogging

The city is vulnerable to waterlogging due to the natural topography, low slope gradients and large geography of low-lying areas. Due to land pressures and increasing encroachments, the natural water bodies throughout the city are dying/shrinking.Twenty to thirty per cent of the city is intensively waterlogged during the monsoon and post-monsoon months. A recent study by Opitz-Stapleton and Gangopadhyay 2008 and utilized in Kull et al. 2008, conducted in the nearby (30 km north) Rohini River Basin projects potential increases in rainfall during the monsoon months (June-September) for the SRES A2 and B1 scenarios under a single general circulation model. Extrapolating the climate change projections from the nearby river basin to the city indicates that flooding and waterlogging might potentially increase in the city due to climate change and landuse patterns.

Vulnerability Analysis for Gorakhpur



Waterlogged areas of city



Sewerage

Only a small part of the city (22 per cent) is served by the underground municipal sewerage system. It was largely constructed in 1960's, with some new installations here and there.The total drain length is approximately 55km and the sewerage disposal is mainly through open drains and sewer lines.The low lying areas, low slope gradient, open drains and no proper solid waste management system in place (causing choking of the drains), increases the vulnerability of city.Waterlogging for long durations also assists mosquito breeding and results in elevated levels of vector-borne diseases, noted in the increasing cases of Japanese Encephalitis in city areas.The sewer lines are also linked to the freshwater bodies existing in the city, causing eutrophication and degradation of these water reservoirs. The city still lacks a sewerage treatment plant.

Solid Waste

The solid waste generation in the city amounts approximately to 300 tons per day and will increase as population grows and access to materials increases. As there is no organized solid waste management in place, the solid waste is a major concern. The increased usage of polythene (plastic) as shopping bags and other items and the throwing of waste into open drains have increased drainage congestion, exacerbating the waterlogging situations. The city has no incinerator to dispose off bio-medical wastes either. With the higher population in the city, the solid waste problems are increasing and contributing to disease loads and waterlogging.

Drinking Water

The underground water table is high in the region and the situation is also the same in the city area. This is the main reason for the majority of the population depending on personal electrified bore well pumps and hand pumps for drinking water. The municipal water supply only covers 65 per cent of the city area.

However, with increasing home densities, poor drainage conditions and high groundwater tables, the groundwater is frequently exposed to contamination. With easy accessibility to groundwater and low levels of literacy and awareness, people tend to depend on shallow hand pumps that provide contaminated water. The physical appearance of the water is not a problem, but the chemical and biological characteristics of water extracted from shallow hand pumps is a problem and induces bacteriological and gastro disorders in a large percentage of the population.

Each of the above problems might appear as separate issues, but they are interconnected and highly related. The synergies between the problems act to greatly exacerbate vulnerability in the city.

Energy issues

The whole of Uttar Pradesh, particularly the eastern districts, is electricity deficient and the supply is much below the demand level. Gorakhpur city has almost 10-12 hours of power cuts per day. As a result, common alternative sources of energy are diesel generators. During monsoon months, approximately 50 electricity-powered pumps are deployed to drain the waterlogged areas, which further contributes to a huge energy drain in the city. Even with such pump arrangements, the duration of waterlogging in various areas amounts to 2-3 days to over a month.

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GIS Enabled Urban Risk and vulnerability Analysis: Indore and Surat for the ACCCRN Project

G.K. Bhat – TARU Leading Edge and S. Chopde - ISET

1.1 Background

Vulnerability surveys of any large city are a complex task due to the immense diversity in livelihoods, access to infrastructure and location-dependant variables. It is also very costly to conduct a census due to the population size, especially in the case of cities with a population over one million. Sample surveys can offer a reasonably good assessment of spatially explicit vulnerability across diverse urban social groups. Geographic Information Systems (GIS) based analysis is essential to understand this spatial diversity, to develop sampling frameworks and also to aggregate the results. Furthermore, vulnerability analyses incorporating GIS can provide information on the spatial distribution of risks and vulnerability in order to explore targeted options for adaptation. GIS, combined with Shared Learning Dialogues (SLDs), aids in understanding the diverse perceptions of various actors (formal, informal and communities) on climate change impacts and vulnerabilities. GIS enabled analysis also provides another basis for conducting SLDs with target communities, to ratify and enrich the information gathered from the analysis. For details on SLD consultations methodology, please refer to the following brochures:

- Shared Learning and Adaptation to Climate Change
- Vulnerability Analysis: Initial Analysis of Gorakhpur City for ACCCRN
- Shared Learning Dialogues: Coastal Tamil Nadu

The GIS analysis described here was conducted in the Indian cities of Surat and Indore as part of the Asian Cities Climate Change Resilience Network (ACCCRN) project. ACCCRN aims to catalyse attention, funding and action on building climate change resilience for poor and vulnerable communities. ACCCRN aims to accomplish these goals by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of various partner cities. More information on the ACCCRN project can be found in the ACCCRN brochure.

1.2 Data availability

In most of the cities, the remote sensing data provides valuable insights into the socio-economic conditions of the resident populations, from settlement types, to road access, and location (core, periphery, and out-growth). One-meter resolution multispectral imagery has been available for most large cities through free sources like Virtual Earth or Google Earth roughly since 2000. These images are sufficient to understand the roof types, and building sizes as well as classification of road infrastructure. Most of this data belongs to the post 2000 period and can be effectively used to classify homogeneous regions.

With the increased permeation of cellular network towers with GPS receivers, GPS measurements are becoming more accurate to within 5 to 30 meters depending on building density and line-of-site to the nearest cell towers and satellites, and compounding errors (Wilson 2001). With the improved accuracy of GPS and satellite imagery, the quality of vulnerability information can be significantly improved by overlaying rapid ground surveys and incorporating this information into GIS. The ground-based data can include building heights, type of building use, socioeconomic status of residents, for example. These have been tested in Lucknow and Bangalore and found to be fairly effective in rapidly classifying the city into various socio-economic categories.

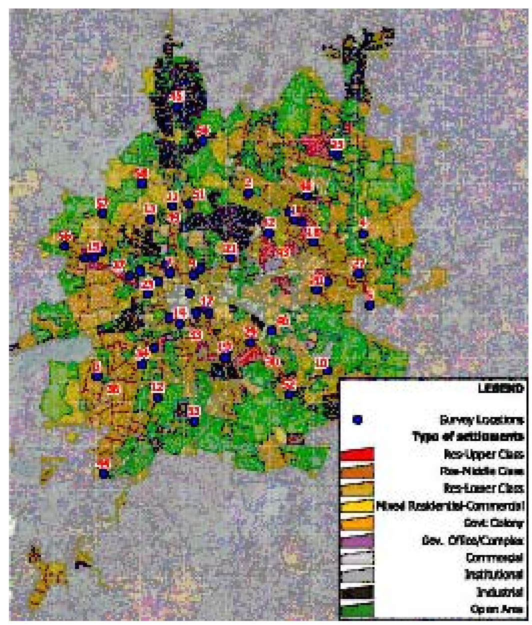
Most of the Indian cities have created tax databases, which include building use, floor area of each unit and other related statistics.These data sets are available from individual dwelling units for all taxpaying households and commercial establishments.The only major constraint is that this data set does not cover slums, especially in the cases of unrecognized slums and other informal settlements.Thus, ground-based assessments are essential in these areas in order to gain a systemic view of full urban vulnerability.

1.3 GIS based analysis framework

The GIS aided urban vulnerability analysis takes advantage of spatially explicit data and uses a variety of indirect indicators to understand the socioeconomic and vulnerability parameters.These include location (core, periphery, distance from markets/industries, etc.), road access, building size and roof types, for example.These data are easily discerned by 1m resolution False Color Composite imagery.The classification schema is further improved by rapid ground surveys.The classification is followed by sample location selection for community and household surveys.The output map with the associated set of attributes is useful for selecting the sample locations and communities. Examples of how GIS based sampling is utilized in assessing vulnerability in Surat and Indore are displayed below.

Sample locations for household/Community surveys (Surat and Indore)

Surat

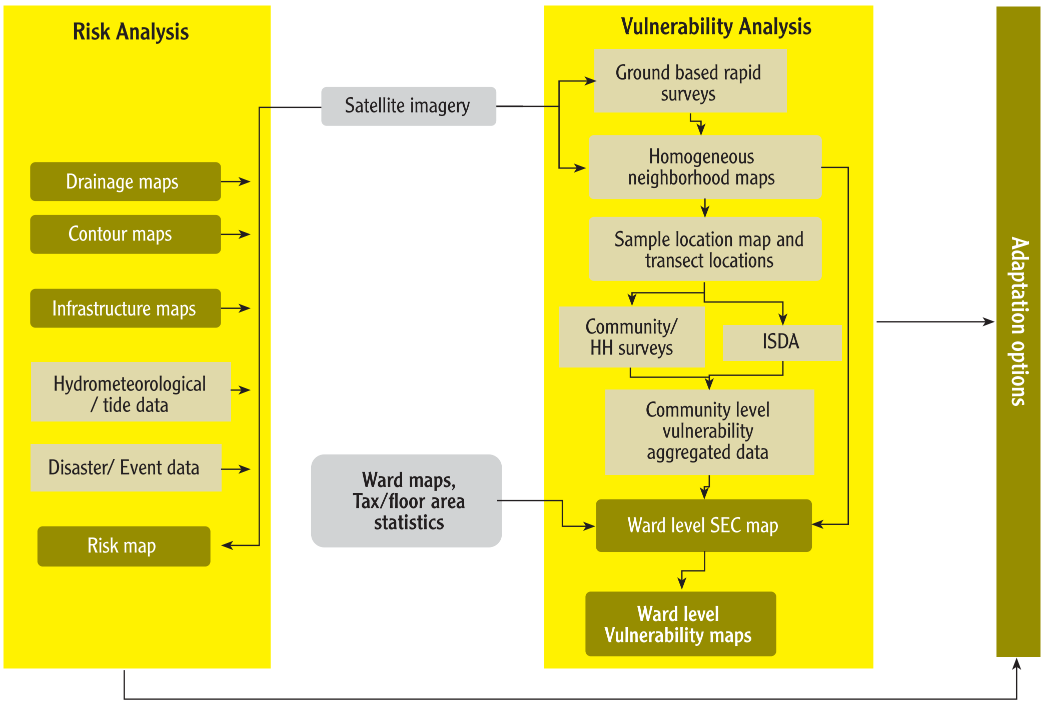


Indore

A rapid (hydro-meteorological) risk analysis in each city was carried out based on past events reported from the city, drainage and contour maps, hydro-meteorological, tide and other relevant data sets. Maps can then be generated that can also be used for selecting the sample sitess for vulnerability surveys.These data can then be further developed to analyse climate risks that include other sectors, such as energy and solid waste management.

The community and household level surveys were conducted at the sample locations in Indore and Surat identified by the GIS mapping. Each cities' household tax database provided a basis for validating the aggregated data information generated from the Infrastructure Services Deficiency Analysis (ISDA), community and household vulnerability surveys. Ward-level data were supplemented by data from slums and informal settlements.The broad framework of the GIS aided urban vulnerability assessments conducted in Indore and Surat is presented in the following figure.

GIS based analysis framework



The homogeneous neighborhood maps provided the basis for ranking the vulnerability assessed for different Socio Economic Categories (SEC).These maps provide a fairly reliable estimate of households with different vulnerability profiles at the ward level. The final vulnerability maps are able to present different facets of vulnerability across Surat and Indore.This information will eventually be used for prioritizing interventions across the city, as well as to provide prioritized mitigative/adaptive options for different groups with different risk exposures.

1.4 Initial Vulnerability Surveys

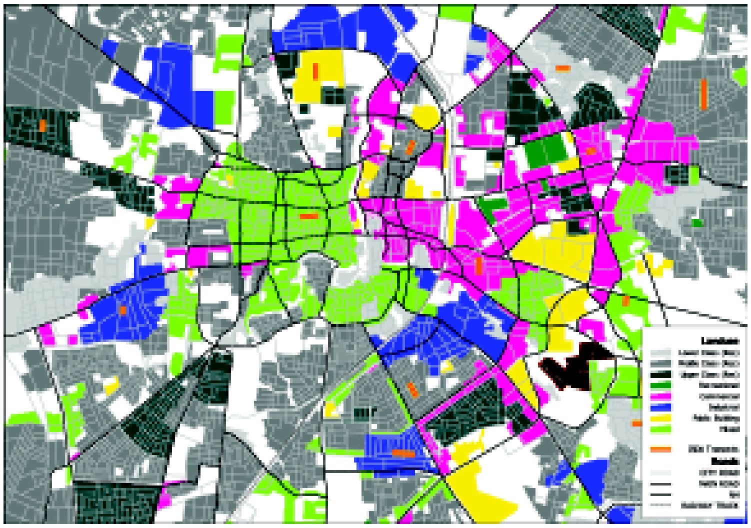
The ground level surveys explored the capacity and vulnerability at both the community and household levels in Indore and Surat.The structured questionnaires were used to elicit information from communities and households.The sample locations decided based on GIS were used to cover all major SECs in the proportion of population estimated from the GIS.The questionnaire covered livelihoods, assets, resource use, risks, scarcity and other related issues. Disaster history and coping strategies were also explored.

The enquiry focused initially at the community level, with separate questionnaires to understand the contextual information and to identify stratification within the community. A set of households was then selected to generate a representative profile of the community.

It was suggested that the community and household surveys be conducted in two stages with intervening community level consultations through Shared Learning Dialogues (SLD).The SLDs provide an opportunity to further improve the survey instruments.The second set of survey instruments can add additional questions, if necessary from SLD outputs.

The vulnerability analyses of Indore and Surat were further bolstered using ISDA. ISDA is a method of assessing the infrastructure conditions based on desired standards vs conditions on the ground. Representative transects in sample neighborhoods are used to assess the conditions. ISDA is a tool utilized to understand the extent of physical vulnerability and also to obtain data on basic services, especially in the case of the poor and in informal settlements. The urban settlements exhibit the highest diversity in access to basic services including water, electricity and sanitation due to reliance on formal and informal services by different groups across the city. ISDA also provides information on population density figures, which can be used to aggregate data to ward and city levels.

Indicative ISDA transects



1.5 Data aggregation

As indicated in Section 1.4, the ward is the first level of aggregation of data. The primary sources of income for urban local bodies (e.g. municipal corporations, municipalities etc.) are house tax and commercial taxes. Each city has a fairly reliable and up to date database on house taxes. The electricity and water utilities also have similar databases, which can be used for assessing the number of households in each SEC based on floor area, type of building, location, etc. Unfortunately, it is often difficult to reconcile the three databases, which follow different schema for aggregation. While the building taxation can be aggregated at the ward level, the electricity and water taxes are often arranged based on different zones, contingent on their respective supply networks. In both water and electricity taxation zones, there are significant numbers of multiple illegal connections that make the task of database aggregation more difficult due to inclusion and exclusion errors. Therefore, the house database was primarily used for Indore and Surat.

The population densities derived from the community level surveys and ISDA transects are allocated to similar homogeneous polygons for example, middle class communities in the core areas. These polygons are derived from satellite imagery analysis in the first stage. These polygons provide a basis for an estimate of the number of houses and population at the ward level. Since ward level data of these two parameters are available, the estimates can be validated and corrected if necessary. The estimates provide vulnerability data across SECs at the ward level in both cities. These data can be further aggregated to the city level.

The SLD process: Towards building Resilient cities

In any programme that aims to build resilience of cities to climate change, a multi-pronged strategy is must. While the above GIS enabled vulnerability and risk analysis is important and useful, the ACCCRN programme needs to catalyse diverse products and outcomes. These results can be achieved through SLDs to meet the multiple objectives, as follows:

- dissemination of project results periodically;
- create awareness about climate change, mitigation and adaptation issues;
- catalyse institutional and policy development around the emerging issues;
- facilitate partnerships with Urban Local Bodies and other key stakeholders (academia, NGOs, private) and communities across diverse spectrum of risks

Effective communication of products is key to meeting the above objectives. The SLD process is unique in many ways and very useful for scoping and identifying vulnerabilities, as well as, building views on issues of vulnerability and risk. This process also builds on strategies and options for urban resilience, and helps to promote a culture of adaptive learning by continual monitoring and learning. The SLD process helps regularly generate and feed key stakeholders with relevant information thru various channels of communication to keep the project live and to retain their interest. One round of SLDs has been held in Indore and Surat, with additional rounds to be held throughout the duration of the ACCCRN programme.

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Strengthening adaptive capability to climate change impacts on land and water: Locally viable technologies and practices-north Gujarat region

M. Dinesh Kumar, O.P. Singh,
Manoj Kumar and Harish Kumara[1]

North Gujarat: A Region in Climate Extremes

North Gujarat lies within western India in the Gujarat plains, a sub-zone of the major physiographic region called the "western plains" (Sontakke *et al.*, 2008). The Gujarat plains have a total geographical area of 66,904 sq. km. North Gujarat, which is the most arid part of this area, is located in the northern portion of Gujarat plains. The North Gujarat region shows major variations in rainfall from 350 mm in the western parts (Santalpur) to 900 mm in the north-eastern parts of Sabarkantha. The rainfall is highly erratic, with the average number of rainy days varying from 25 days in the Banaskantha district (eastern side) to 35 days in Sabarkantha on the western side (IRMA/UNICEF, 2001).

High inter-annual variability in rainfall is one of the striking features of this region. Rainfall in Palanpur for the period from 1901 to 1990 shows a coefficient of variation (CV) equaling 50.2%, while the mean annual value remains at 682 mm. Within the same district, at Radhanpur, which is just 100 km away, the mean annual rainfall is 496 mm, with a CV of 59.6% (IRMA/UNICEF, 2001). The high year-to-year variation in rainfall, sandy soils and evaporative loss from soil caused by high temperatures, wind speed, and extremely low relative humidity alter the area's hydrology. These combined variables cause disproportionately higher variation streamflows and groundwater recharge in the region (see Figure 1). The high frequency occurrence of droughts in the region (Ray & Wale 2001) is also due to the highly variant hydro-climatological variables, leading to shortage of water for irrigation & drinking, as well as fodder (IRMA/UNICEF, 2001).

Climatic variability, however, is not a new phenomenon for the region's communities. Analysis of data over 124 years shows that the region has been subject to multiple droughts in the past century (Ray & Wale 2001). During these droughts, the thousands of ponds that dot the region, dry up. However, water for irrigation, cattle drinking, and domestic use can be obtained by the communities' utilization of manual labour and animal power to dig wells and pump the groundwater.

Increasing Vulnerability to Climate Variability

The socio-economic changes the region has experienced during the past 4-5 decades were brought on mainly by population growth and the introduction to modern farming. These shifts have altered the regional water resource landscape. The shallow, manually operated wells and those controlled by draught power were gradually replaced by electricity or diesel powered pump wells. While well-irrigated areas increased remarkably, the shallow aquifers and a large number of village ponds dried up. Additionally, the region became one of the largest exporters of dairy products in the country.

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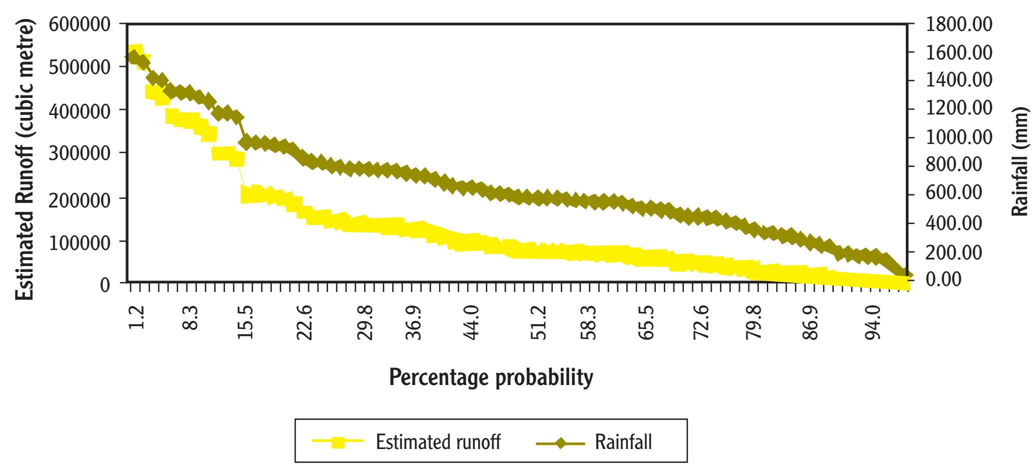
Modern dairy farming introduced in the region brought water-intensive alfalfa along with it and created the need for irrigation in the summer months to produce green fodder. The market infrastructure provided by the milk producers' cooperatives encouraged farmers to move towards intensive dairy farming, thus increasing the need for growing water-intensive fodder crops (Kumar and Singh, 2008). The deep tube wells utilized with submersible pumps and subsidized electricity perpetuated mining of the aquifers. The expensive tube well method for irrigation kept many of the poor small and marginal farmers without irrigation. The region's agriculture became heavily dependent on groundwater. The communities are now fully dependent on imported water and wells in order to meet basic survival needs.

This is one of the most agriculturally prosperous regions of the country. However, the groundwater problems seem to have been aggravated by rainfall changes during the last 4-5 decades, as well as the growing demand irrigation water. The rainfall decreased during the period from 1856-1899, increased until 1959, and started declining from 1960 until 2006 (Sontakke *et al.*, 2008). However, the analysis of rainfall over the past 150 years does not show any consistent long-term trends.

Figure 1: Probability of Occurrence of Rainfall and Runoff in Banas basin



Agricultural water use is very intensive in the region. Dairy farming was found to be the most water-intensive component of the farming system, as one litre of milk requires 2.5 to 3.2m^3 of water (Singh 2004). According to the 2001 estimates, a total of 447m^3 of water is used per capita of human population in Gujarat, against a per capita renewable water availability of 427m^3/annum per capita (IRMA/UNICEF 2001).

During dry years, aquifer replenishment is reduced and pumping goes up, upsetting the water balance severely with excessive watertable drawdown and well failures. It is important to note that unlike conventional crops, where farmers reduced winter crop area during droughts, it is difficult for farmers to discard highly productive dairy animals to minimize their water demands. Dairy farming is the backbone of Gujarat's rural economy. A study in some villages showed that it accounted for nearly 70% of the surplus value product from irrigated agriculture. Hence, the vulnerability to drought is high.

Future Climate Change Impacts

If the region experiences a rise in temperature in the future, its impact on rainfall could be negative due to high aridity and lack of soil moisture during the summer months (Trenberth 1999). Based on the rainfall-runoff relationship existing in the region, a reduction in rainfall for any particular year can create a disproportionately greater reduction in annual runoff and groundwater recharge (see Figure 1).

Historic trends of rainfall in India, particularly for Gujarat, show higher variability of rainfall in locations with lower rainfall magnitudes (Kumar 2004). It is likely that rainfall variability will increase under various climate change scenarios. While the overall mean values of streamflows and groundwater recharge could reduce sharply, future flow variability could be extremely high. Flow variability is already very high in rivers. The 20-year dataset for streamflows in the Banas River shows that the flow (at Deesa)[2] varied from a minimum of 12.37 MCM in 1987 to 1872.92 MCM in 1994, with the reservoir overflow being significant (Dept. of Narmada 2001). Such increases in variability will have large impacts on irrigation systems dependent upon reservoirs and groundwater pumping. Communities living in areas downstream of the reservoirs are also impacted negatively during 'bad years'.

The region has fifteen medium and large reservoirs allotted for irrigation and drinking water purposes. All of these reservoirs are over-allocated, and have dependable flows much less than the water demand from their design commands and drinking water sectors (Kumar *et al.*, 2000). Over the years, an increasing share of water from these reservoirs is being allocated for municipal uses and rural drinking water. This is due to the deteriorating quality of groundwater from deep aquifers (high levels of fluoride and total dissolved solids), as well as domestic use. Reducing inflows would eventually jeopardize the interest of the farming communities. In the absence of an alternative water source, farmers could increase the rate of groundwater mining. On the other hand, the rural and urban water supply sectors would also be badly affected by this.

Coping Mechanisms of the Communities

The communities in the region applied social ingenuity to sustain irrigated agriculture by designing and nurturing institutions for exploiting groundwater. However, this has only helped in sustaining access to groundwater, which is quickly depleting. The decentralized water harvesting and recharge schemes promoted by the government in the region fail to make any positive impacts. The water supplies they provide are highly unreliable and do not provide enough water during 'bad years' (Kumar *et al.*, 2008a). Given the high demand for water, the high variability in annual hydrological events, and the likely changes in the region's water resources due to future climate change, water management options are limited. Options to either engage in large-scale surface water imports or to largely cut down the water used for agriculture leave little to be desired.

The communities are quite aware that the region would soon run out of water unless major interventions are made to improve the region's water balance. Inter-basin water transfer would help (Ranade and Kumar 2004), but it is difficult to obtain an increased share from Narmada for the long-term. The present share from Narmada would just be sufficient to balance the reduction in groundwater area caused by over-exploitation. In some areas, communities are compromising their daily water needs by reducing the frequency of use for washing and bathing. In irrigated areas, major reductions in kharif crops and irrigated winter crops have been seen in years of droughts.

Strategies for Adapting to Climate Variability and Change

Adaptation to changing conditions in water availability and demand has always been at the core of water management. The IPCC defines climate change adaptation as: 'An adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits benefit opportunities'. Climate change adaptation clearly focuses on *climate-related hazards*, such as floods, droughts and storms. Vulnerability of people and ecosystems to climate change and variablity results from a combination of external and internal pressures, sensitivity to changes, and coping capacity (IPCC 2001; Hoff 2004). The project initiated by the International Water Management Institute, under the North Gujarat Initiative (NGI), became instrumental in changing the mindset of official agencies, NGOs and communities. It helped convey the idea that building more groundwater recharge schemes does not assist in tackling droughts. Additionally, it communicated the need to find a lasting solution to the crisis and that the resolution lies in water demand management within agriculture.

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2 This is the estimated virgin flow at Deesa, a gauging point d/s of Dantiwada dam, and was calculated from the inflow in the dam (less than the gross storage) and the observed streamflow at Deesa.

Three strategies were introduced: promoting micro-irrigation[3] (MI) systems for agricultural crops, introducing highly water-efficient, high valued crops and organic farming practices. While the farmers were quite convinced of the utility of MI devices introduced for improving crop water productivity, the challenge was in aligning the social interests with the private interests of farmer. One major disincentive for the farmers was in moving away from a farming system like dairy farming, which provided stable income and regular cash flow. The existing pricing of electricity in the farm sector and the absence of groundwater ownership negated incentives for the farmers, as water and energy saving does not lead to cost saving (Kumar *et al.*, 2008b). Although the yield enhancement was a good incentive, the potential incremental benefit was not perceived to be very significant for many of the dominant crops grown in the region such as wheat, bajra, jowar and mustard.

However, crops such as pomegranate and lemon were introduced as they have low water- demands and resilience in times of acute scarcity. The high-income return from these crops was another attraction. The constant input provided to the farmers expressing the ability to manage their crops with a small amount of water, therefore sustaining an income was a strong enough incentive for them to try it. Since micro technologies are highly amenable to these crops, most farmers immediately chose adoption of the MI systems.

Strengthening Adaptive Capabilities

With the adoption of the MI technologies, the following were the notable changes in the farming system found in a survey of 114 adopters. The area farmed for potatoes, as a percentage of the gross cropped (GCA) area, increased by 19.5%, while the newly introduced pomegranate occupied 1.5% of the GCA. This shift is mainly because the technology adoption itself was associated with farmers becoming motivated to try new crops that were more amenable to such systems. Also, some farmers were seen expanding the area of crops for which they initially adopted the system, thus replacing traditional crops. At least some reduction in the cropping intensity was seen, as the average gross cropped area of the individual farmer went down from 3.96ha to 3.22ha. The average farm income rose up by Rs. 99442 per annum, and was most significant in the case of orchard growers. What is important is that not only the water productivity of all crops increased remarkably (see Table 1), but that most of it came from a rise in net income and a reduction in irrigation water usage for all crops. Crop water productivity with MI systems was found to be highest for chilli and pomegranate.

Table 1: Impact of Micro Irrigation Technologies on Crop (applied) Water Productivity on Selected Crops in North Gujarat

Sr. No	Name of Crop	Crop (applied) Water Productivity (Rs/m3)	
		Before adoption of WST	After adoption of WST
1	Potato (micro sprinklers)	7.04	17.99
2	Cluster bean (micro sprinklers)	7.68	15.77
3	Pomegranate (drips)	NA	41.37
4	Groundnut (micro sprinklers)	4.13	9.36
5	Cotton (drips)	10.32	18.81
6	Chilli (drip)	34.87	148.1

Source: authors' own analysis based on primary data, 2009

Because pomegranate and lemon have a gestation period of 1.5 and 3 years, respectively, it was difficult for the resource poor, small holders to wait after heavy capital investments. One way to overcome this was by encouraging farmers to go for inter-cropping of fruit plants with vegetables such as bottle gourd, bitter gourd, and watermelon. Inter-cropping methods provided them high enough returns to recover the entire cost of drip system installation while waiting for the fruit plants to begin producing.

[3] The term "micro-irrigation" is generally applied to all methods of low-flow water irrigation at or below the soil surface. It includes such techniques as drip or bubble-spray irrigation.

A major criticism of the NGI strategy at the project commencement was that large-scale adoption of MI systems and water efficient crops would not necessarily result in a reduction in groundwater draft. It was argued that with a reduction in water requirement per unit of land achieved through water use efficiency improvements, the farmers would expand the area under irrigation by using the "saved water" (David Molden, IWMI, personal communication). Furthermore, according to McCornick who cited the example of the country Jordan, with higher income from every unit of water pumped, the farmers would be tempted to invest more in well irrigation for growing high valued cash crops (Peter McCornick, personal communication). However, the project outcomes proved these criticisms wrong in Gujarat.

Another important criticism of the strategy was the increased dependence of the project on MI systems for improving regional water productivity. Some critiques argued that use of MI systems would only result in "applied water saving" and not "real water-saving". According to them, the return flows under conventional methods of irrigation would be available for reuse, and the real water saving could occur only if there was a reduction in crop evapotranspiration (Molle and Turral 2004; Howell 2001). However, by virtue of the deep vadoze zone in the alluvial aquifers of north Gujarat, the return flows are generally not available for reuse, and instead, are part of the total water depleted water. This depleted water consists of "non-recoverable deep percolation" and soil evaporation (see Allen *et al.* 1998 for details). Hence, MI adoption might actually lead to saving of water in the aquifers, even though there are reduced return flows.

The water and energy saving benefits from the use of MI systems do not result in income benefits for most farmers who pay for electricity on the basis of connected load. However, the project showed that it is possible to motivate farmers to adopt water-saving MI systems without providing subsidies. One strong incentive was the reduction of drawdown in wells, and the consequent reduction of well failures experienced by the earlier adopters. This was mainly due to the drastic reduction of pumping, resulting from improved water productivity. The other incentives were higher crop yield and income.

The indirect impacts of NGI interventions are much larger than the direct impacts. The impacts of the extension activities went beyond the project villages and farmers to many villages within the same and neighboring talukas who also adopted the new technologies. While the total cropped area brought under MI in the 120 NGI project villages was 2750ha, the MI cropped areas in outside villages and talukas was 21,537ha (Kumar and Sharma 2009). The greatest impact of the interventions was enhanced knowledge of farmers about the technologies and crops that are most favourable for arid environments like that in north Gujarat, including mulching.

Concerns for Future

Efficient irrigation technologies and water-efficient crops will help farmers overcome the stress caused by climate change and variability by being able to manage irrigated agriculture with less water, without compromising its economic prospects. Unfortunately, the poor farmers, especially marginal farmers, do not have the socio-economic wherewithal to adopt most of these systems, with the exception of organic farming practices. Soft loans are therefore being offered to marginal farmers to buy MI equipment by the Society for Integrated Land and Water Management (SOFILWM). SOFILWM is the organization mandated to pursue the NGI strategies in north Gujarat and other semi arid regions of India. Additionally, new systems have to be designed for poor water-buying farmers to use MI devices in their fields, with suitable cropping patterns that give high returns to offset the high cost of the system.

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Adapting to Water Stress and Hazards: Case of the Kosi River Basin in Bihar, India

Praveen Singh - Winrock International India

People in the Kosi River Basin in Bihar, India, have developed livelihood strategies that have partially helped them adapt to the regular cycle of floods, erosion and waterlogging. Traditional practices in the floodplains mainly depended on flexible land-use and flood adapted cropping practices. During the colonial and post-colonial period, various welfare and development schemes, and the construction of structural flood control measures, encouraged people to change their lifestyles and livelihoods. These changes led to significant alterations of the area's agro-ecological settings and, over time, adversely affected the people living in this basin. Yet the communities have responded to these and many macro-level changes by adapting to the hydro-climatological and engineering challenges in this basin. For instance, an alternate system of land-use and cropping is being adopted in many parts of the basin. Most of the individual, autonomous adaptive strategies are geared toward intense cultivation of the land during the short cultivation period. However, there are other strategies emerging that are related to asset protection and livelihood diversification, such as protecting food, fodder and fuelwood, drinking water and housing from floodwaters or migration. Some of these strategies emerging in response to the socially influenced, hydro-climatological hazards of the Kosi River Basin are analysed below. The villages surveyed in the Kosi Basin prior to and after the embankment breach of August 2008, were visited under the aegis of the "Too Much Water, Too Little Water" programme supported by the International Centre for Integrated Mountain Development (ICIMOD).

Adjustments in the cropping cycle / pattern

In the villages that suffer river flooding almost every year, (i.e. villages unprotected by embankments or trapped between an embankment and the river), growing *aghani* paddy during the monsoon season (June-September) is a risk as the fields are flooded on an almost annual basis. Nonetheless, the people broadcast paddy in these lands every year with the hope that the crop might survive if the flood levels are low and the fields do not remain waterlogged for long periods of time. Historically, the risk of planting paddy pays off with a bumper crop on average, every three years. The floodprone land is capable of supporting a good crop in the *rabi* season depending on where the river is flowing. If the river has deposited a thick layer of sand (sandcasting) then crop survival is minimal and the yields are low. However, if the river has deposited a good layer of silt, then these lands produce a very good crop of wheat or maize, as well as some *bhadoi* crops like *managera* and *moong* (pulse).

The *garama* cropping season (sown in February-March and harvested in May-June) is new to the Kosi Basin. The new crop represents an adaptive response to the acute problem of waterlogging in villages/lands close to embankments or outside of embankment protection. Acreage under this new variety of paddy, generically called *garama dhan,* has increased in the past several years. Much of the waterlogged and seepage areas in a narrow strip (about 3-5 kms wide) along the river's embankments are beginning to witness increased cultivation of *garamadhan*. Garamadhan, a coarse variety of paddy, is grown mostly for household consumption, as compared to other rice varieties, it does not command a good price at the market. Its cultivation is clearly an adaptive response to the flood situation and is beginning to provide a measure of food security to poor households.

New and better varieties of crops

In the past few years, hardier and higher yielding varieties of crops have been introduced to the basin.The new varieties of wheat and maize seed give much better yield than before. Even high yielding varieties of vegetable crops have been introduced. However, apart from new varieties of traditional crops, new crops have also been introduced. For instance, the introduction of **sunflowers** in villages prone to river flooding (unprotected and/or trapped between the embankments) was in response to lands being waterlogged for up to four months or longer[1] . It is a commercial crop and returns a good profit because its cost of cultivation is low. Further, sunflowers out-compete weeds and improve soil productivity. An early maturing, high yield variety of **maize** of recent origin - the late 1990s – has been introduced to the basin in response to early-arriving floods. Now the crops are harvested by May, much before the first floods.This has given a lot of hope to the farmers whose main crop is maize.These new crop varieties are introduced by private seed marketing companies and most often are tried first by entrepreneurial or big farmers before others follow.

Makhana (*Euryale ferox Salisb*) is the major aquatic crop cultivated in the waterlogged fields. Makhana is a nutritious non-cereal food and is used for preparation of various kinds of sweets and recipes. It produces starchy white edible seeds. For growth of the plant, a maximum of one-meter deep (standing) water is required. Its cultivation is dependent on water availability (standing), soil type and climatic conditions. Large areas of waterlogged lands and other water bodies in the basin are now used for makhana cultivation.The fishing community (Mallah) depends upon it for their livelihood because of the decline of local fish stocks. Even though makhana cultivation is difficult, it does fetch a good price at the market. A growing demand for makhana is evident through the increased involvement of private sector companies.

In lands lying within the embankments, and those unprotected by embankments, sand-casting is a major problem. However, a number of Muslims who are expert vegetable farmers lease these lands for **vegetable farming**, which are able to support a number of vegetables, especially those of the cucurbit family[2] .Vegetable farming is also widespread in other villages that are closer to urban centres. New and high yielding varieties have increased the profitability of this farming and helped the landless Muslims improve their lives and incomes.

Better cultivation methods

Farmers in the area have developed practices, which prevent degradation of land or soil fertility despite intensive cultivation of already declining land.These practices are also workable for the short period of time when land is available for cultivation. Mixed cropping and rotation cropping are used to maximize crop yield and also to keep soil fertility intact. Mixed cropping of crops within the same piece of land, for instance maize with garama dhan, maize with moong or maize with bajra and moong, are common. In many places, field bunds are used to grow teak trees or managera plants. Using the same water body for makhana cultivation and pisciculture is also very common. Managera and moong, apart from their other uses, are good for nitrogen fixation and are especially sown to reclaim the fertility of the soil.

Addressing water needs for irrigation: the use of bamboo bore-wells and movable pumping sets

Bamboo borewells were first introduced in this region in the early 1970s.The advantage of this type of borewell is its low cost and the local availability of the necessary materials. Expertise to dig bamboo borewells has developed locally and hence, there has been an increase in the number of borewells in the region.The cost of boring a bamboo tubewell of about 80 feet depth is about Rs. 7000-8000 (the cost of conventional boring is at least 5-6 times more), and the life of

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[1] While embankments prevent some lands from being flooded, they also serve to trap floodwaters in lands lying between the river and the embankment. Prior to the myriad of flood control structures implemented in Bihar and Uttar Pradesh, the lands were accustomed to low-level flooding almost every monsoon season.The low-level flood waters provided much needed nutrient-rich silt to the land, and typically subsided within a few days.

[2] The curcubit plant family includes plants such as melons, cucumbers and gourds.

such borewells is about 10 years. A bamboo borewell can easily irrigate about one acre of land. Increased usage of bamboo tubewells has not only increased the intensity of land use by small and marginal farmers, but it is in a way, also addressing the wide income disparity common in the region.

Movable pumping sets are also easily available for rent in villages and can provide additional income for the owner. These pumping sets are mounted on small bamboo carts, which can be moved from field to field to service each borewell/field. The existing rent rate is Rs. 60 per hour of pumping. Diesel/kerosene for the pump and the plastic pipes to transport the water are provided by the pump owner. Those who do not own a borewell have to shell out an additional Rs. 5-10 for pumping water from a private borewell.

Animal husbandry

Animal husbandry as a livelihood option had supported large section of the population in the pre-embankment days[3] . The construction of embankments, barrages and other infrastructures resulted in a reduction of the vast open *ramnas* (grasslands) and an increase in waterlogged area, which in turn has led to a significant reduction in the cattle population. While rearing milk cattle has decreased in most areas in the basin, the rearing of small ruminants (mostly goats) has increased. The lower castes and classes (Musahars, Muslims) mainly rear small ruminants, as these are easier to manage (even during floods), feed and also fetch a good market price. Like share-cropping, share-rearing of goats is widespread in this region. An adult, yearly male goat fetches about Rs. 1500 in the local market.

Migration and remittance

Migration has always been an important livelihood option for people living in the floodplains, especially for the asset-challenged. However, migration increased after the construction of embankments and in response to stress caused by the resulting changes in basin agro-ecology. The disruption in the aghani crop season, and to some extent in the rabi season, has forced both the landed and landless labourers to look for employment opportunities outside the region during these seasons. In these villages, about 80% of the adult males migrate during off-farm season. Most of the migrant workers leave their villages after completing all agricultural activity of the garama season (end of May or beginning of June) and come back when their land is fit for cultivation, either in the beginning of the rabi season (early November) or garama season (February).

Migration and finding work in far-off places has become easier with the improvements in transport and communication facilities. Many households have some degree of information and social networks that aid the household in finding work outside the village. The pattern of migration has been changing from largely rural-rural (to Punjab, Haryana and western U.P.) to rural-urban migration (to Delhi, Mumbai, Pune, Surat). The composition of the migrating population is also undergoing changes; now, even the lowest classes and castes are migrating.

Access to loans has also improved. Even though the traditional money lending castes do not operate in this region, the relatively better-off people act as moneylenders in the villages in the Kosi Basin. In most cases, small amounts of money are provided without any collateral, but with high interest rates. Yet, these small amounts of money are generally required before migration in order to cover the cost of travel and to provide some cash to women/remaining household members to sustain the household until remittances can be sent. For those not migrating, money borrowing is generally required before the agricultural season in order to buy seeds and fertilizers. Local shopkeepers also provide goods on credit and charge an interest rate on deferred payments. With the improvement in rural banking, sending remittances has also become easier.

Overall, migration has become a very important adaptation strategy to the changing nature of hydro-climatological hazards and socio-economic and agro-ecological stress in the basin. In the future, migration is expected to increase further with growing population pressure on land resources and increasing employment opportunities in economic

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[3] The history of embankment construction and flood control policies in Bihar, and the resulting consequences, are discussed in the policy brief "The Kosi Floods: Embankment Failures, Climate Change and Tipping Points".

growth centres within other parts of India. However, as many observers feel, migration might decline with the introduction of 'employment guarantee' schemes in rural India.

Housing, food and fuel storage systems

Most of the houses in the Kosi Basin are *kutcha* and made of local material: built of a bamboo frame, with a bamboo screen covered by a plaster of mud/cow-dung, and thatching of locally available grasses or crop residue. However, these houses are being built on a higher plinth in all the villages, more so in unprotected villages and those trapped between the embankments, as an adaptive strategy to the flooding. In these villages, houses are built on top of the debris of the older houses.The plinth level is built higher than the maximum flood level of past floods. Residents of these villages are confident that the river will first over-top the embankments before entering their houses. In many of the households, especially those who can afford it, tubewells are also part of the raised homestead land. In villages suffering from perpetual waterlogging, the plinth level of the houses is not as high. However, new houses, especially *pucca*[4] ones, are being constructed at higher plinth levels.

In the floodprone villages, remittances from migrating family members are mainly used to build pucca house with flat roofs.The flat roofs enable the house to become a point of refuge during large floods, where people can move their assets and shelter in place until the floodwaters recede. Most of these houses have a partial double roof; the one inside the house is used to store important assets and valuables.These are also used as points of refuge for elders and children especially during high flood years. Most of the houses also have fixed platforms made of bamboo which is used for keeping household items, or for sitting and sleeping.The height is purposely kept above the last flood level.

Food (mainly maize and rice) is stored in every household in cylindrical shaped structures constructed from mud and cow dung, along with strips of bamboo.The levels of these grain storage structures are being raised as an adaptive strategy. *Machans* (raised structures made of bamboo) are generally used to store fodder.The fodder is covered with plastic sheets during monsoon months. Cow dung cakes in the region are round and bigger in size, making it easy to be stored and transported to safer locations in times of emergency. Another form of cow-dung cake is made out of dung and mustard stalk, and is readily used as a replacement for wood during floods.

Drinking water and sanitation

Pollution of drinking water sources and a lack of access to potable water during floods is a major problem in the Kosi basin.The majority of the population is dependent on hand-pumps for domestic water use. Since the groundwater level is just around 25-30 feet and the cost for installation of a hand pump is currently minimal, many better-off households have installed hand pumps within their courtyard. However, the poor households in most of the villages must share a common government hand-pump.The quality of water from these hand-pumps is unsuitable for consumption - there is a very high content of various minerals (iron). In response, locally made water filters are now being promoted by a group of NGOs. Water from open masonry wells is also being used in some places for drinking.The walls of some of these wells have been raised to a level higher than that of the maximum historic flood level.This work is being supported by NGOs as well. In many other places, NGOs are also promoting rainwater harvesting through simple structures made of bamboo and plastic.These catchment systems are utilized by people stranded on embankments and other high places during floods, or those permanently forced to relocate to embankments because their lands are perpetually waterlogged.

Sanitation conditions in these villages are poor. Only 10-20 households in each of the villages surveyed have access to a sanitary latrine, which is used only by women or used for storing fuel and fodder. Open defecation is common, and people either go on high ground or use boats to defecate during floods. Alternate, temporary structures made of bamboo and plastic sheets are constructed and are used for defecation during floods by some. No arrangements are made for safe disposal of the waste.There is clearly a need for raising awareness and also a need for investments towards improving sanitation and water resources in these villages.

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[4] Pucca houses are generally constructed out of baked brick or stone, with solid (non-plant) material roofs, such as tin or tile.

Factors Influencing Local Adaptation

The ability of communities to adapt to floods, droughts and climate variability is influenced by the changing contexts in which their livelihoods are embedded. Environmental degradation and climate change are altering the natural resource base on which most agricultural-based livelihoods depend. Additionally, other changes in markets and market access, communication technologies, transportation and social and political set-up also influence the way communities are responding to climate and ecological variability.

The loss in access to productive assets due to embankment breaching, waterlogging and the changing course of the river is a common phenomenon within the studied project sites. Deposition of sand around the fertile agricultural land after the embankment breach of August 2008 has caused a substantial loss of assets.Various drainage schemes have failed to improve the situation as well. Officially, all lands outside the embankment are considered protected. However, the reality is that these lands have lost their productive capacity temporarily or even permanently because of the conventional flood control structures.This loss is not compensated in any way by the state.There clearly is an **absence of a rehabilitation and resettlement policy over the loss of land due to failure of flood control measures.**

On the other hand, due to the relatively easy access to private agricultural credit and the recent penetration of private seed and fertilizer marketing companies, there seems to be a revival of agricultural growth. New and improved hybrid seeds have made their presence felt within the nearby towns through aggressive marketing strategies by the agricultural companies. New methods of cultivation, for instance System of Rice Intensification (SRI), have also been popularized with the help of some NGOs. Remittances have also increased and helped to increase investments in agriculture. However, most of these innovations are happening at the individual/household autonomous level.The state extension services are almost absent.

Poor access to markets, coupled with inadequate infrastructure for food storage act as constraining factors for adaptation. However, there has been some improvement in transportation systems, which has facilitated the movement (migration) of workers to areas with potential demand for labours. Despite increased investment in transportation networks, there are still areas in the region that remain inaccessible and cannot access easily access markets.

Banking in rural areas has improved to a large extent. However, there are still a lot of problems: poor and illiterate people still find it difficult to open an account with the banks and have to depend on other bank account-holders to send their remittances.This frequently leads to pilferage of their hard earned money. Alternatively, many of the poor have to depend on the informal village moneylenders to avail credit and face extortionist lending rates as there is no regulation.

There has been a sea of change in the **telecommunication** sector within the selected project areas. Access to mobile phone networks has helped the population to keep in touch with their potential employers or for farmers to find the best selling prices at nearby markets. Besides facilitating movement of labour, access to telecommunication systems has helped in early warning. Flood warnings and weather forecasts, for example, are being sent to mobile phone owners.

The **National Rural Employment Guarantee Scheme** (NREGS) aims to provide 100 days of employment locally to all households within all the districts in India.This scheme has not only the potential to alleviate poverty, but also assist in building community and household assets that could be used to deal with floods. However, the scheme has been only partially implemented in the Kosi Basin.The inefficiency and corruption of the bureaucracy at multiple levels has been preventing this policy to achieve its ultimate objective. Furthermore, some of the structures being built through this scheme would hardly qualify as enabling adaptation. Bad governance also leads to limited impact of many other poverty alleviation and environmental management programmes rolled out by the government. In short, while there clearly are enabling factors for encouraging autonomous and planned adaptive strategies to develop in the region, there are many hindering factors as well that need to be addressed.

The Kosi Floods: Embankment Failures, Climate Change and Tipping Points

Praveen Singh

Introduction

The Kosi River is popularly known as the "Sorrow of Bihar" because of its frequently shifting courses and the devastation it has caused. In August of 2008, the Kosi broke through its embankments and now flows in a newly created channel some XX kilometers from its original channel. The basin is home to a huge population, which is affected by both hazards related to the river and water stress. However, the inhabitants of the basin also benefit from the waters brought by the river. North Bihar is naturally inclined to suffer from flooding due to the regional topography. The region is very flat, with several major rivers flowing down from the steep Himalayan Mountains north of the basin. This causes north Bihar and the surrounding region to be especially vulnerable to flooding, however, this is only part of the story.

In the past, the blame for such calamities was placed upon Nepal for releasing waters from the irrigation barrages in its territory. Ironically, the barrages are manned by Indian engineers. Many others have also attributed the growing intensity of these flooding events to climate change, even though it is not possible to prove such an assertion as yet. Such pronouncements only serve to excuse state authorities from moral responsibility for a problem they have clearly caused through poor planning and lack of mitigative action. Historically, structural measures such as embankments or barrages were adopted in an attempt to mitigate flooding and waterlogging associated with the river. However, the impacts of these measures have been significant, with areas prone to flooding and waterlogging only increasing over the years due to insufficient planning, construction and maintenance of these structures. On the other hand, the large areas in the basin are also frequently affected by drought.

Unfortunately, we continuatively debate the possible solutions while the people of the region are suffering. The discussions, previously and even now are mostly centred on short-term technological choices, rather than longer-term non-structural adaptations.

Colonial legacy

The East India Company officials (circa the 1800s) were perturbed by the disruption caused by the annual inundations of the rivers and the resulting, constantly changing landscape of the floodplains of eastern India. Armed with the dominant scientific discourse of the time, they failed to learn from the more flexible practice of land revenue administration practiced in pre-British era. Additionally, they did not adopt the adaptive practices of the farming in the region. The difficulties that these inundations presented in administering even the most rudimentary/skeletal state structure in the region, (mainly collecting land revenue) led them to devise methods to control the rivers and other water bodies. Embanking of rivers was largely promoted and received enthusiastically by landlords. The colonial state itself did not make any big investments in this region, as it was settled under the Permanent Settlement[1] .

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[1] For details on the Permanent Settlement Act, and the previous zamindar system of land taxation, refer to Guha (1996) or Keay (2002).

In no time the negative effects of the embankments started being reported from different corners of the province. With the advent of crown rule, administrators sough to tighten flood control management. However, by then the landlords, strong allies of the colonial state, were already privately benefiting from flood control measures and not keen to relinquish control to the crown. The region witnessed a phase of competitive construction of embankments. The introduction of railways and road networks with high embankments and minimal waterways further worsened the flood/drainage situation. Not surprisingly, by the end of the colonial era, the engineers and a number of administrators had witnessed the inefficacy of embankments. They began to question the policy of controlling floods in the plains. However, they began speaking of constructing retention basins in the hill, which was a significant from previous policy. The Indian nationalist leaders, on the other hand, criticized the colonial state of not investing enough on agricultural development and wanted to maintain the status quo. For example, the nationalists thought they should be focusing on flood control embankments and perennial canals.[2]

Post-independence boom

Post-World War II marked the era of Multi-purpose River Valley Development (MPRVD) and the US emerged as a leader in this new enterprise, providing both expertise and funds to developing economies (D'Souza, 2003). In Bihar as well, the post-war plan included construction of a high level dam on the Kosi at Barahkshetra in Nepal. After years of investigations and dilly-dallying, the dam project was shelved and an alternate project was sanctioned. The new project involved the construction of continuous embankments: 125 kilometers along on the eastern bank of the river, from Birpur to Kopadia, and 126 kilometers long, from Bhardah in Nepal to Ghonghepur in Saharsa on the western bank. The embankments were completed by 1959 and were meant to protect 2.14 lakh hectares of land from the recurring floods of the Kosi. A barrage across the river was also constructed in 1963 near Birpur, to facilitate irrigation of 7.12 lakh hectares of land through the Eastern Kosi Main Canal. Another canal, the Western Kosi Canal, is currently being constructed to irrigate some 3.25 lakh hectares of crop land on to the western side of the barrage (Mishra 2008). The foundation stone of this canal was laid way back in 1957, however, the work on this canal is still progressing! The same model of flood control and irrigation was followed in other river basins of north Bihar.

Despite the additions in total length of embankments, Bihar remains one of the most flood-prone states in India and has the highest number of flood-affected people per capita. The area threatened by floods has risen continuously since independence: flood-prone areas increased to 6.9 million hectares in 1993 from 2.5 million hectares in 1952 (GoB 1994). Within Bihar, the North Bihar plains are the most affected by floods, with 73.6% of the area of North Bihar being flood-prone (GoB 2008). With such a large area lying under water for much of the year, survival is difficult in this region. This is primarily because 87% of the population depends on agriculture for their livelihoods. The water from the canal networks has also failed to reach the fields in time or adequately for that matter. This is due to lax maintenance and massive under-utilization of the newly created irrigation potential of the Kosi canals (GoI, 1973). In short, modern engineering solutions have failed to cope with the problems that they initially created. The state that once had a surplus of food before independence in 1947 is now suffering a chronic food deficit.

Politicians who gave their stamp of authority to more engineering-based solutions over a more people-centred approaches, repeatedly have blamed Nepal and upstream dams to avoid responsibility for improper maintenance and authorization of poorly planned structures. A river-linking project has also been dangled recently to assuage the growing discontent. Post-disaster relief and structural measures, most of which do not reach the needy, remain the only state measures actually being implemented.

The Changing Agro-ecology of Kosi basin

In the pre-embankment times, people in the floodplains had adapted to the agro-ecological setting and were accustomed to low-levels of annual flooding to replenish the soil with silt. They had their own system of floodplain zoning and a flexible land-use system. For instance, people living close to the river mostly grew *bhadoi* (sown in May and harvested in June, a 60-day crop) and *rabi* (sown in November and harvested in March) crops, while those living

[2] For details on the colonial debates see Singh (2008)

far from the rivers grew mostly *aghani* crops (sown in June-July and harvested in October).This was done because of the annual overflow of the rivers during the monsoon months, which did not allow aghani crops to be grown in villages close to the rivers.Within each village, there were different categories of lands depending on soil type and elevation (lowland, highland).These lands were put to use for various purposes and different crop types based on the aforementioned variables (Singh 2003). Animal husbandry was an important livelihood option in the region as there were huge swathes of grasslands (*ramnas*) for grazing. A lot of these traditional land-use systems have disappeared with the growth of population, extension of cultivation, loss of traditional cropping patters, flood protection measures and other infrastructural developments in the region.

After embanking the Kosi, four distinct areas emerged in the landscape. In each of these areas, the nature of water hazards is different.The first zone is the area trapped between the Kosi embankments. Nearly one million people in 380 villages are trapped between these embankments. Erosion and sandcasting of the land has become intense in these villages. Despite these problems, this was the one area that has hope of receiving fertilizing silt from the river's floodwaters. Contrary to the common belief, agriculture within the embankments had improved considerably (GoI, 1977).

However, people living in the embankment-protected part of countryside, but close to the embankment have their own tales of woe.They live in constant dread of the embankments breaching[3] and do not sleep at night during the rainy season.They have very little time to move to high ground in case of a breach.The distress due to this problem is very evident, particularly in a strip of land about five kilometers wide along the embankment. Here, a significant portion of agricultural land remains waterlogged for most of the year and no agriculture can be practiced. Furthermore, areas directly in line with the Kosi discharge during and after an embankment breach take years to return to normal conditions.

Large sections of the population who live in unprotected stretches of the river also face the adverse impacts of embankments upstream. Beyond Ghonghepur, the river is free to wander on its western side. Rivers like the Kamla and the Bagmati join the Kosi on its western bank.The combined water of the Kosi and its tributaries makes life difficult for these unprotected villages.

Areas that are further away from the embankments or river have benefited from the Kosi project, as they generally do not have to deal with the bankcutting and meandering of the river. Most of these areas came under the command of the Kosi canal system and were promised a better life. Unfortunately, things have not been as rosy as promise; there is a massive underutilization of the irrigation potential in spite of the canal system (GoI, 1973). However, as the experience of the floods of 2008 show, even this zone is not safe from devastations caused by embankment failures.

North Bihar has also regularly faced droughts.The state receives about 1300-1700 mm of rainfall each year (GoB, 2009), most of it falling during the four monsoon months. Since the rains are uncertain, both in terms of quantity and timing, crop yields are regularly affected even if the rains do not completely fail.This is largely because most places have only rain-fed systems for agricultural purposes.This is especially true for the kharif crops, where a lack of rain during critical phases of the crop's lifecycle can result in a 75 % crop loss. A comparison of records from 1966-67 to 1986-87 reveals an interesting fact: the flood prone districts of north Bihar are as susceptible, if not more, to droughts as the districts of south Bihar and Jharkhand. Interestingly, the Khagaria district, also known as *dooba zila* (submerged district), suffered drought conditions in seven of the 20 years!

The impacts of the changing landscape and the nature of floods have been immense on the general well-being of the people. People's livelihoods, mostly related to agriculture, are adversely affected due to the increase in waterlogged areas, sand-casted areas, and also land lost due to erosion. Again, the impact has been differentiated in different zones. For instance, people from the first three zones do not have any other option but to migrate for work during June to October or even December, depending on the location of their village).This is necessary during these times when agriculture is not feasible due to river floods or waterlogging. Animal husbandry and pisciculture are two livelihood

[3] So far the Kosi embankments have breached eight times and details of first seven breaches are available elsewhere (Mishra 2008).

options that supported a large percentage of the population in the pre-embankment days. The construction of embankments, barrages and other infrastructures has resulted in the reduction of the vast open *ramnas* (grasslands), contributing to a significant decrease in cattle population. Obstructions in the flow path of the rivers and neglect of ponds and reservoirs have resulted in a reduction of fish stock and in the variety of fish. This has adverse impacts on the livelihoods of the fishing community (Mallahs) who had to shift to other activities. The impacts on education, drinking water, disease and other aspects of human well-being have also been adverse.

Future scenarios- Climate change

Many people, such as John Holmes, the United Nations Undersecretary General for Humanitarian Affairs, have invoked "global warming" as the cause for 2008's extreme flooding in the Indian sub-continent (Holmes 2009). There might be some truth to these pronouncements, though as yet unproveable, as studies and projections have suggested that climate change will influence streamflow patterns through: (i) changes in the precipitation, (ii) changes in the volume and timing of snowmelt from glaciers, and (iii) changes in the type of precipitation- snow or rain- in the Himalayan region. The perennial rivers originating in the High Himalaya receive their water from snow and glaciers. The warming trend of the last fifty years has resulted in greater rates of snowmelt than of snow accumulation. Melting glaciers result in increased water flows in the initial years, followed by a decline in flow as the ice resources decline. According to some studies, a 2°C rise in mean global temperature will increase the average flood discharge in the Ganga, Brahmaputra and Meghna rivers by as much as 15%, 6% and 19% respectively (Mirza et al. 1998). Apart from changes in snowmelt and precipitation in the Himalaya, changes in the pattern, intensity and frequency of rainfall will have significant impacts on floods. Undoubtedly, the state machinery and the people will have contend further with the increased fury of nature under climate change.

On the other hand, the embankment breach of August 2008 happened when the Kosi's discharge was only 144,000 cusecs (on 18 August). The Kosi embankments were designed to accommodate a flow of up to 950,000 cusecs. The maximum recorded discharge in the Kosi was 913,000 cusecs on October 5, 1968. This previous discharge resulted in the western embankment breaking in five places in Darbhanga. Clearly, the embankments are failing on a regular basis and with discharges much lower than the average discharge during the monsoon. The embankment failure of August 2008 is only an indication of what could come in the future. There is clearly a need of a rethink way we deal with rivers like the Kosi.

Ways forward

Technological fixes have not served the flood control purposes intended by either the state or the affected communities. Considering the uncertainty in precipitation projections made by climate change experts and the expected increase in climate variability, structural measures will increasingly fail in providing relief to the people. Rather these poorly planned and maintained structural measures will only exacerbate the intensity of flood events and waterlogging. Many individuals and organizations, including transnational NGOs such as Oxfam and ISET, have strongly advocated increasing the adaptive capacities and resilience of the communities to cope with extreme events like floods (Oxfam 2007; Moench and Dixit [Eds.] 2007; the Risk to Resilience Team 2009). Reforming the existing state programmes and policies should be the first step toward adopting more people-centred approaches. Many civil society organizations and para-statal agencies have also developed good practices to cope with floods. These practices need to be incorporated into government programmes and further upscaled over larger areas. Structural measures will have to be gradually phased out. This is easier said than done considering the strong interest groups that have developed around these structures. However, these changes could be brought about through an inclusive political process, rather than through a techno-managerial approach. Bihar's policy-makers owe it to their populace to empower local communities with respect to flood control and more generally, to economic development. Anything less means that the next flood, during the next monsoon season, will wreak similar or even higher damages on the population, their livelihoods and assets.

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Adaptation in practice: Water Transitions: Helping the Formal and Informal Urban Water Sectors in Developing Country Cities Adapt to Climate Change

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Background

Water resource managers in developing country cities face complex challenges including the lack of infrastructure and adequate management mechanisms to provide for the needs of populations, the web of different water sources accessed by residents, and multifaceted relationships with the informal water sector. Climatic variability adds a new dimension to these challenges, and requires a new set of tools to help water resource managers understand the potential impacts of climate change and create some planning strategies to provide resilience in the face of change.

The project is the collaboration of two of the leading international NGOs working on the science and policy of climate, water resources, management, and adaptation: the Pacific Institute and the Institute for Social and Environmental Transition (ISET), working together with TARU Leading Edge, our India based partner. The goal of this project is to develop a framework, as well as a few key tools, to guide water resource managers in the formal sector in understanding the potential impacts of climate and social change on water resources and in developing a process to address these impacts. Through detailed dialogues in an urban area in India, and potentially one in Southeast Asia, we will bring together water stakeholders including water managers, NGOs, and the private sector to identify key needs that water stakeholders have in responding to climate change.

Due to decaying infrastructure, lack of funds, and a variety of other problems, the formal water sector is only able to provide sporadic service to many urban dwellers. Migrant populations and informal settlements in peri-urban areas are not served by the formal water sector. As a result, most urban dwellers rely on the informal water sector to supplement or completely fulfill their water needs. Furthermore, the potential impacts of climate change on the water supply and demand cycle rarely enter into the planning and management strategies of the formal sector. The informal water sectors do not even consider climate change and often lack the economic capability to engage in long-term strategies. The dynamics of economic and natural resource migration, with some migrating only on a short-term basis, coupled with the impacts of climate change and social change on water resources, have the potential to completely overwhelm formal urban water sectors in India. This situation is not unique to India, however, and is descriptive of the situations that face many developing country water managers.

Project Goals

We are researching the practical adaptation strategies that urban water managers in South Asian cities can make that complement the autonomous adaptation strategies undertaken in the informal sectors and are resilient to a wide variety of as yet unknown climate impacts and social change. The research will help guide the development of a framework of action, consisting of a suite of resiliency tools, that enable the formal urban water sector to flexibly respond to a variety of uncertain climate and socio-economic scenarios. The flexibility and resiliency of the tools developed from this project will be designed for applicability in other developing country contexts.

This project will develop a set of tools to help water managers assess their water system for resilience to climatic and social variability, identify and evaluate potential adaptation strategies, and create a process to deal with climatic and social change. Developing frameworks to enable communication between the formal and informal water sectors is an important aspect of this project. We will work at the formal and informal sectoral level in order to identify strategies vital for both. The outcome of this project will be a broad framework within which water mangers can operate, as well as a set of key tools. We will not seek to create specific models or analytical packages to guide water managers from specific climatic predictions to a predetermined set of mitigation strategies. When we use the term "tools," we mean processes for evaluating climate impacts and identifying mitigation options, successful frameworks for organizing information, and effective approaches to evaluate the resiliency of different adaptation strategies

Project Outcomes

From July 2008-December 2008, we conducted a comprehensive review of existing tools in climate change and water – and identified key gaps, including the failure to address the particular needs of utilities and communities in developing countries. We selected the city of Indore in the central Gangetic Plain in the Indian state of Madhya Pradesh as the site for shared learning dialogues (SLDs) to understand the needed tools. From December 2008-July 2009, four intensive field visits were conducted in Indore through SLDs, focused group discussions (FSDs) with various stakeholders, and over a dozen project team meetings.

We developed three questionnaires for water managers at all levels that formed the basis of discussions for meetings and group discussions. We also collected primary and secondary data, which will be corroborated through ongoing surveys planned in each community. We surveyed numerous community-based organizations, conducted detailed field visits in five communities and met with numerous formal water sector managers, informal water sectors, builders, developers, and NGOs.

We have undertaken detailed surveys and focused group dialogues with all of the key actors in the water sector in Indore, including communities, NGOs, formal water managers, and private sector water suppliers. Activities undertaken so far have enabled the team to broadly identify and rank, on a scale of 1-5 where 5 is most severe, the major concerns that each of the water mangers identified and to also highlight key responses from formal and informal water mangers on transparency/ information/ decision-making/ connectivity tools needed for better water management. Outlined below is a summary of major concerns and tools identified by each stakeholder.

Formal Water managers: For the formal water managers who come from a state-centric paradigm of understanding water supply and demand, water scarcity is largely understood in terms of techno-engineering. Shortage in supply and burgeoning population are cited as root causes of water scarcity. Current water supply is largely met through the Narmada River (nearly 80%) and through 42 tankers of the Indore Municipal Commission (IMC). For effective monitoring of the water supply system, Nigam Parshads (Ward Members) link the people and the IMC. Narmada Phase III, according to officials, will not only fill in the present gap between supply and demand but is expected to meet the demands of the 40,000,000 population estimated by 2023. For improved water conservation, the IMC is planning to make water conservation mandatory at all levels and to formulate a policy in this regard soon.

Informal Water managers:

1. **Communities:** Scheme No 114: all four communities share common concerns: water availability is ranked 5 (most severe), water quality ranked 4, cost of water is ranked 3. Common responses on tools they need to better manage water are:
    1. Information on water-recharging techniques and support from government and other agencies
    2. Common boring needs to be propagated by the IMC
    3. Total ban on direct water motors to check the misuse and theft of water
    4. IMC should help set up infrastructure required for recharging of the grey water, and generate more awareness on how to better manage water
    5. Water recharging must be made mandatory by IMC, and IMC should make provisions to monitor the recharging process

6. Some houses have installed rainwater harvesting, but they need support from the IMC to help set up the infrastructure
7. Information on Narmada Phase III and how the supply will enhance their current water usage
8. Construction of overhead tanks in Nayapura community
9. Regular Narmada water supply and improvement in present water supply
10. Information on how to maintain water quality and inexpensive methods available
11. Information on best water conservation and management practices
12. Use of media for information dissemination with NGO support for all mentioned needs
13. Information on artificial recharging
14. More awareness generation on how to better manage water

2. **Private water tankers, Niranjanpur village:** Niranjanpur is a rural area within the IMC's jurisdiction. Approximately 50%-60% of Indore's water demand is fulfilled by private tankers from this village. According to the tanker owners, there will be no impact from the Narmada project as demand is increasing every day while the dropping groundwater level will affect their business. The biggest threat perceived by the private tankers is from the IMC which is trying to take control of their hydrants.

3. **NGOs and Academic Institutions: Centre for Environment Protection Research and Development (CEPRD) and Shri Govindram Seksaria Institute of Technology and Science (GSITS) College:** Main reason for water scarcity is unequal social distribution of water; poor and faulty water management; water theft and loss. Important alternatives that can improve transparency, connectivity for better water management are: reasonable tariff structure; proper distribution system; zonal planning; need for good statistical data which needs to be verified; comprehensive integrated planning by an agency; good networking between the departments responsible for water supply and management; systematic study of future demand; regular demand-supply audits; a transparent public address system.

4. **Builders and Contractors:** better communication among large builders about new practices of water and energy conservation; need for a policy on water harvesting in buildings; awareness generation among the general public and large builders/ architects on best water conservation and management practices; coordination between the Indore Development Corporation (IDA), the Town and Country Planning Office (TCPO) and IMC for proper development of the city.

In the next phase of our project we are getting detailed information at the community level about their key coping strategies for water scarcity. Through a limited household survey we will be getting data on coping strategies, needed information and transparency tools, and venues for dissemination of climate change adaptation tools and strategies.

In the next 10 months, we will be creating a foundation paper on what is needed in terms of tools for communities in facing water insecurity as a result of climate change. We will also develop a self-reliance water tool for communities to be more robust in the face of water insecurity.

Adaptation in Practice: Freshwater Fish Farming in Tamil Nadu

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Pilot Implementation in Pushpavanam village

Pushpavanam village belongs to the third ecosystem where agriculture is the main occupation, but cultivation is carried out through the seed broadcasting method. This village is quite vulnerable to seawater inundation. This village is an *island village* because it is surrounded by water on all sides: on the eastern side by the Bay of Bengal and the remaining three sides by the Uppanaru River, a backwater river. Therefore, the impending threat of sea-level rise is quite likely to affect this village very badly. We realised that in the years to come the impact of climate change might be more severe in this village as the seawater has already moved inland by about 100 meters in the past 20 years. This has resulted in high levels of salinisation of coastal agriculture lands. At present the productivity has diminished significantly, by 50% in the past 10 years, and in the coming years might decrease further.

As the groundwater is also somewhat saline, there is absolutely no water source for irrigation. Since no irrigation facility is available in this village, paddy agriculture is very much dependent upon rainfall. During a short period immediately post-monsoon, the groundwater has been recharged and is fresh down to a 10ft depth. But it quickly turns saline during the summer months. When drought hits this region, water scarcity, even for drinking, is a serious issue. There are approximately 50 shrimp farms in the area, which contribute further to the salinisation problems. Fishing stocks in nearby rivers, coastal areas and the canals have been seriously depleted by overuse of the *Surukku valai*, a type of fish net.

The entire village population, consisting of 1779 households, is vulnerable to the above threats. However particular populations, such as the landless agricultural day labourers, the elderly and women, and those who do not have access to private transportation, are constrained from seeking jobs elsewhere. Less educated or illiterate and the Scheduled Caste (SC) are also quite disadvantaged.

How were interventions identified?

In this village, as in Pichavaram village, farmers were asking for structural interventions such as shutters/ tailend regulators and the construction of a huge and lengthy wall along the seashore. Other demands included a mangrove forest / vegetation safety belt (bio-shielding) along the coast by planting fruit trees, community radio and the establishment of a juice / pulp unit to help the ongoing mango cultivation in the village. The project team suggested a few other options like: computer training, improvement of communication skills, spoken English training for the local students, Eco-san toilets, TCPL (Tree Cultivation in Private land) under the Union Government scheme, fresh and/or brackish water fish culture in the existing 40 village Panchayat ponds, poultry farming, domestic animal rearing (goats, sheep and cows), pig farming, and vocational training for the local youth, for example as automobile mechanics or seaweed cultivators. A series of SLDs over a period of 15 days with different groups helped to identify these livelihood options for a possible pilot intervention. Finally, the freshwater fish farming was chosen as a pilot intervention.


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In the following monthes, our main focus lay in doing a thorough vulnerability assessment of the village and in deciding on the implementation that would best benefit the most vulnerable in a way that would help them to choose a more resilient livelihood option. We carefully analysed the options raised by the village during the SLDs. The idea of starting our own community radio seemed a bit problematic since the required capital was quite high. Further, after the end of the project term, neither the village community nor the village Panchayat were keen to shoulder the responsibility of maintaining and operating the radio. Shutters and seawalls were not considred, as such structural interventions may not prove sustainable given the high chance, but uncertain level of sea-level rise. We did consider the TCPL (Tree Cultivation in Private land) under the Union Government scheme for the Pushpavanam village. Poultry farming, domestic animal rearing (goats, sheep and cows), pig farming were taken up by some local NGOs in Pushpavanam. Therefore, we did not want to repeat those interventions. Pushpavanam is not very suitable for seaweed cultivation due to unsuitable soil and climatic conditions.

After considering all the above options, we found that the most suitable option for Pushpavanam village is freshwater fish farming. This village has around 40 Panchayat ponds, of which 20 ponds are used for bathing and for cattle use and the remaining 20 ponds were for agricultural purposes. Furthermore, almost every house has its own pond, which is used for irrigation (plants grown in the garden) and for domestic purposes. We had a number of discussions and SLDs with the village community, Panchayat members, SHG members, and fisheries officials and found that some of these ponds could be converted into fishponds. This was expected to generate a substantial amount of income in a 7-month period.

Who does it particularly benefit?

This particular intervention was attempted while keeping in mind the entire village population. This is a unique case where there are 40 village ponds that belong to the village Panchayat. Besides, every farmer owns a small pond (of the


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size ranging from 0.20 acre to 0.50 acre) on his or her farm.The idea is to demonstrate a profitable way of making use of small ponds by growing freshwater fish in these ponds as an alternative livelihood option in an environment in which agriculture is failing miserably due to high soil / groundwater salinity and cyclonic storms. After considerable discussion with the Fisheries Department, the village community in consultation with the village President, selected the largest 6 Panchayat ponds for fish farming for pilot intervention and one more Panchayat pond (Ayyankulam) was selected to benefit a female SHG belonging to the SC community.

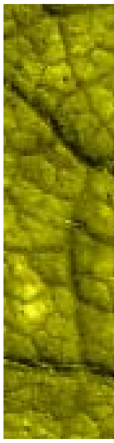
What are its limitations?

The biggest limitation of this project is that once a pond is set aside for fish farming, the water from the pond cannot be used for any other purpose. A few villagers in this village were vehemently opposing aquaculture and the use of fish feed in the ponds.They argued that as all of the ponds are village ponds that are used for domestic purposes, the fish pellets that are added to the pond make the pond water dirty.Therefore, they argued that they did not feel comfortable using the same pond water for domestic needs.There was a heated argument and we could appease the situation only temporarily. A longer-term solution equitable to all parties has yet to be found.

How widely applicable is the intervention?

This is a location specific intervention. Aquaculture intervention requires hundreds of ponds or else the farmers should be prepared to spend money on creating ponds to develop fish culture.

This intervention concept in our view, as emerged from the SLDs, appeared quite promising.This village has already been experiencing the threat of seawater encroachment to the extent of losing 100 meters of land during the last 20 years.This has resulted in increased salinity of soil and groundwater. Furthermore, this is an island village surrounded by water brackish water and seawater on all four sides.This is very frightening for the villagers. On the whole, profitable agriculture in the village was seemingly out of question. At the same time, this is a unique village endowed with 3779 small private ponds and 40 community ponds that sounded extremely promising for developing alternate livelihood option. We hoped to have a demonstrable effect on the livelihood options of the village so that all others could follow this as a profitable venture for sustainable living. On a regular basis, the Panchayat or SHG's or individuals could earn additional income by cultivating fresh water fishponds. In the future, if the lands are completely saline because of seawater flooding due to climate change, the freshwater fish culture might be the only livelihood source in this village for those unable to migrate. Given the resource endowment of this village, fish farming in many small ponds appears very promising for diversification to livelihoods that are non-land based.



Adaptation in Practice: The Case of Tamil Nadu Demonstrating Livelihood Diversification

The Tamil Nadu interventions presented in the following set of brochures were part of a larger program investigating the challenges of climate change and disaster risk reduction in Tamil Nadu. The SLD and vulnerability analysis pieces (in separate brochures) outline the existing prevalent responses by the people and the government. The Cauvery River delta, which encompasses the whole of Nagappattinam District and parts of Cuddalore District, is a low elevation coastal zone with few areas 10 meters or more above sea level. 56% of the land lies below sea level and an additional 18% of the land lying just at sea level is waterlogged and marshy. The delta is crisscrossed by a 1,800 year-old irrigation system comprised of a complex network of canals, rivers, channels and drainage system. Due to its flat terrain, the region is prone to flooding from drainage canals and seawater, particularly during the October to December northeast monsoon when most of the rain falls in the span of a few days and is often combined with cyclones or high wind storms.

Because people have been living in these areas for so long, their livelihoods have actively shaped and are shaped by the ecosystem zones in Tamil Nadu. Three distinct ecosystem zones were identified along the Tamil Nadu coast:

- The **first ecosystem** encompasses marine and backwater river reaches where fishing is the principal, or often the only, source of livelihood.
- The **second ecosystem** represents areas in which both fishing and agriculture co-exist.
- The **third ecosystem** is the one in which agriculture is the main occupation, but cultivation is carried out through the broadcast method (seeds are tossed by hand over a broad area, rather than planted in furrows).

Each ecosystem-livelihood zone has unique climate-related vulnerabilities that will be further exacerbated by climate change. Additional human-related pressures, such as the large number of chemical industries located on the beach and discharging effluent directly into the sea or backwater rivers, are challenging the viability of traditional livelihoods. For more information on the methodologies utilized to catalogue the vulnerabilities and identify interventions, refer to the following brochures on the Tamil Nadu study:

- Adaptation in Practice: Computer Training in Tamil Nadu
- Adaptation in Practice: Emu Farming in Tamil Nadu
- Adaptation in Practice: Freshwater Fish Farming in Tamil Nadu
- Shared Learning Dialogues: Coastal Tamil Nadu

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The villages selected for the interventions currently face problems with accelerating coastal erosion, cyclones and storms, ongoing flooding, waterlogging and inundation due to backwater floods, storm surge and high tides, increasing salinisation of land and groundwater and occasionally drought. The adaptation processes and strategies discussed in

the brochures examine the current vulnerability and potential impacts of climate change on the aforementioned hazards. They also explore how to help the villagers cope with current and future climate hazards. Given the land-based nature of current livelihoods and their vulnerability to climate variability and change, the only truly sustainable, long-term solutions promoting adaptation are those involving livelihood diversification.

The pilot implementations were carried out in order to test and analyze adaptations in practice. The interventions were restricted to II and III ecosystems, namely, TS Pettai and Pichavaram in the second and Pushpavanam in the third ecosystem (see Table 1 for demographic details).

Table -1 Population, number of households, number of hamlets and area in the selected villages of Eco-systems (ES) II and III

Name of the village & Ecosystem	Population			Number of households	Number of Hamlets	Total area in sq. km	Density of population per sq km
	Male	Female	Total				
ES-II Vanagiri	3670	3622	7292	1603	9	8.01	910
ES-II TS Pettai	554	569	1124	281	2	3.17	354
ES-II Pitchavaram	2550	2500	5050	614	6		664
ES-III Pushpavanam	3150	3100	6250	1779	11	8.60	726

Source: Field survey 2007-08

Adaptation in Practice: Disseminating Climate Change Knowledge in the Nepal Tarai: Radio Dramas

Ajaya Dixit and Kanchan Mani Dixit
ISET-Nepal and Nepal Water Conservation Foundation

Globally, the literature recognizes climate change as one of the most serious threats to sustainable development with possible adverse impacts on the environment, human health, food security, economic activity, natural resources, and physical infrastructures. Global climate varies naturally, but scientists agree that the rising concentrations of anthropogenically produced greenhouse gases in the earth's atmosphere are leading to changes in both macro- and microclimates. In recent years, climate change has become a key focus of scientific and policy-making communities and is now a major area of discussion in the multilateral climate change fora such as the UNFCCC. There is consensus among almost all scientists and governments that climate change will directly alter risk patterns.

Because of its complex and variable natural geography, climate change is a critical issue for Nepal, one of the world's least developed countries. Disparities and instabilities in the social context heighten the challenges. Scientists suggest that in general climate variability in Nepal will increase, but most studies focus on the recession of the Himalayan glaciers and the expansion of glacial lakes. The IPCC (2007) indicates that within the next two to three decades, glacial melt is likely to increase flooding and rock avalanches from fragile slopes and affect regional hydrology. The IPCC also projects that river flow will decrease as glaciers recede. The problem is far more complex than the receding of glaciers and the melting of snow. More than 50% of Nepal's population lives in the Tarai, which will not be affected directly by glacial melt. Nonetheless, the impact of climate change is likely to be severe in the Tarai, with the rivers being prone to flooding and bank-cutting. Sediment eroded from the upper regions of rivers is transported to their lower reaches and deposited on the Tarai plains. As rivers cut their banks and shift laterally, they create serious problems, such as causing loss of land and crops, the very basis of people's livelihood. Increasing our knowledge about the changing nature of climate impacts will help minimize disruptions.

How do the insights of science shared with local mountain, hill, and Tarai communities of Nepal impact livelihoods? Does local-level understanding match global-level understanding of climate change? These questions necessitated an iterative inquiry into existing knowledge about global climate change, its adaptation to the Nepali context, and its accessibility to local populations. The process began with an analysis of sectors and issues related to climate change in Nepal in through shared learning dialogues (SLDs). We reviewed the literature and government policy and also interviewed experts involved in the climate change sector. We held discussion with the media personnel about their understanding of climate change and methods of disseminating information.

These steps led to the identification of several themes, including the use of fossil fuel-based energy as the cause of global warming, greenhouse effects, and the impacts of increased rain and snowfall patterns and glaciers as well as on flood, droughts and watershed management. The use of renewable energy sources such as carbon neutral safa tempos (three-wheeled electric vehicles) and carbon displacing bio-gas plants were identified as being crucial. In addition, the Clean Development Mechanism and the Kyoto Protocol were recognized as important aspects of the global outlook on climate change and politics. Finally, it was recognized that various agencies involved in climate-related issues play important roles.

After summaries of the issues identified were prepared in English, the next step was to convert the material to a format that could be communicated to general audiences.The question was how to do so and what medium to use.The shared-learning dialogues with the media revealed that FM radio would be most cost-effective and that radio drama, in particular, would be useful. Earlier experiences have shown that radio dramas can stimulate the curiosity of listeners depending upon how the issues are presented and integrated.The format selected was named *Jal Bayu Puranas* or Climate Recitation after the traditional practice of reciting *purana* (religious stories).The preparation of the drama was a major challenge because climate-related topics had to be communicated to a group of non-technical people, in this case, radio-drama actors. It took almost six months of intense work to prepare a script of seven episodes covering the climate change issues mentioned above.

The drama was enacted by members of a drama production house representing different climatic regions of Nepal: the higher Himalaya, the Middle Hills and the Tarai.They spoke their local language during the drama so that they would reflect the contemporary political discourse on social inclusion.Then, the drama was broadcast over three FM radio stations; Lumbni in Butwal, Rupandehi District; Parsa FM in Birjung, Parsa District.The stations were selected to cover the Rohini Basin in Nawalparasi and Rauthaut districts. Prior to making the decision we conducted a preliminary survey of the coverage, the popularity of the station, and their willingness to broadcast the programmes.The dramas were broadcasted via Nepal FM in Kathmandu Valley. Subsequent to their broadcast, a random assessment was done to solicit feedback.

Listeners found the programme interesting and said that the content helped them appreciate climate change and its impact. Nonetheless, climate change was generally considered a remote event, something important only at global level, like Al Gore receiving the Nobel Peace Prize. Listeners said problems like access to reliable basic services such a drinking water, sanitation, health and education were more serious than the impacts of climate change. The ongoing violence in the Tarai was identified as another serious problem.Yet, they also identified many indicators of local changes that could be attributed to climate change.The listeners suggested that such radio programmes be broadcast in local languages to localize knowledge.They also suggested that global knowledge needs to be synthesized with local understanding of weather and climate.

Clean Energy Nepal, a national-level NGO dedicated to promoting clean energy in Nepal broadcast the radio drama through other FM stations. Climate adds a new layer into a social system undergoing transformative changes and makes the context more uncertain. Addressing the challenges will involve many different stakeholders and cannot be addressed through prediction and control alone. Instead the approach adopted needs to be adaptable to information generation by the changing global and local context. Radio drama was one innovative way of grappling with this challenge.

Adaptation in Practice: Early Warning Systems in Tamil Nadu

Vijay Pratap Singh - Ekgaon and S. Janakarajan
– Madras Institute of Development Studies (MIDS)

The Tamil Nadu interventions presented in this set of briefs were part of a larger program investigating the challenges of climate change and disaster risk reduction in Tamil Nadu. The SLD and vulnerability analysis piece (in a separate brochure) outline the existing prevalent responses by the people and the governments in coastal Tamil Nadu. The Cauvery River delta, which encompasses the whole of Nagappattinam District and parts of Cuddalore District, is a low elevation coastal zone with few areas 10 meters or more above sea level. 56% of the land lies below sea level and an additional 18% of the land lying just at sea level is waterlogged and marshy. The delta is crisscrossed by a 1,800 year-old irrigation system comprised of a complex network of canals, rivers, channels and drainage system. Due to its flat terrain, the region is prone to flooding from drainage canals and seawater, particularly during the October to December northeast monsoon when most of the rain falls in the span of a few days and is often combined with cyclones or high-wind storms.

Pilot interventions were carried out in four different villages in coastal Tamil Nadu: Vanagiri, Pettai, Pitchavaram and Pushpavanam. Interventions other than the early warning systems and TV distribution are discussed in the following brochures:

- Adaptation in Practice: Computer Training in Tamil Nadu
- Adaptation in Practice: Emu Farming in Tamil Nadu
- Adaptation in Practice: Freshwater Fish Farming in Tamil Nadu
- Shared Learning Dialogues: Coastal Tamil Nadu

SMS for Early Warning

Mobile phone use in the state and also in the selected villages is very high. The number of mobile numbers in use within each of the villages as of February, 2008 when the assessments were conducted is as follows: Pushpavanam: 410, Vanagiri: 385, Pichavaram: 202, and TS Pettai: 39. Roughly 70% of the households have at least one mobile number. We decided to make use of the high incidence of mobile phone to send weather alerts and create an early warning system. In collaboration with Ekgaon Technologies and Tamil Nadu Agricultural University, we (MIDS) started initiating this activity in all the villages to gage how the technology was being used and attempted to uncover the factors inhibiting effective early warning SMS.

The weather alert through SMS started flowing on 17th of March 2008. The main weather information was sent four days in advance of an oncoming weather disturbance through SMS and consisted of wind speed, humidity, and rainfall. Time was definitely a concern, especially for fishermen at sea who need time to bring their boats in, and there were many instances when the message did not go through. During the months of April and May 2008, pilot villages did not receive any early warning messages at all. Furthermore, even though the SMS forecast is sent four days in advance, it often reached the recipients with a one or two day delay.

When we asked for the feedback from the mobile users, we were informed that they did find it interesting. However, the content of the weather alert SMS did not seem to thrill them. Many were not able to read the message since it was in English. A primary drawback for using mobiles to create an early warning network rests on the model of the cell phone and its ability to accept local language scripts. We had to inform the pilot participants that they could receive SMS in English only. Even those who could read English found it difficult to understand the abbreviations used, though they picked it up after they were briefed on the details contained in the SMS. Yet, others did not understand the concept of humidity and how it might be applicable to their livelihoods.

The general opinion that emerged after the first pilot attempt was that there was nothing special about the routine weather information being sent via SMS, that it was not in an understandable language. When asked what specific agricultural activity the forecast was used for, they replied that they had not found the information useful for any agricultural activity. Most of them felt that weather information through SMS would be extremely useful if it was agriculturally focused information, such as the nearest market price trend for major agricultural products, availability of seeds and price levels, availability of fertilizers, etc. On the whole, the objective of this exercise was to establish the use of this service and technology for sending weather information. What was uncovered was that information needs and the ability to understand and utilize weather information by various communities was different than we thought when we piloted the intervention. Obviously, there is vast scope for improvement. However, once fully developed this medium of communication, the cell phone, could play a vital role during times of emergency needs.

Despite the initial limitations found, the mobile phone is likely to be quite useful for early warning during extreme weather conditions. Therefore, Ekgaon Technologies, Tamil Nadu Agricultural University, and MIDS are planning to enable climate alerts in such a way that people are able to use them. This would mean sending the alerts in Tamil to suit the needs of farmers as well as fisher-folks. This would also mean that the users could call the designated helpline and get alert messages in their area using a voice-based menu. Local language voice recognition technologies will be used in this application. We plan to test this service for a period of three months to assess the user feedback.

Television for Sending Weather Alerts

The Government of Tamil Nadu is giving free TV sets to every household that does not already have one. Nearly 7 million sets have already been distributed in rural and urban areas. People in the selected villages have all received free TV sets. Another 4 million sets are currently being distributed. Therefore, during the course of the next year, literally every household in the Tamil Nadu State will have access to a TV set. The Government of Tamil Nadu has started what is called The Arasu (State) Cable TV Corporation with the mission to provide cable connections to households at a highly subsidized cost.

Every corner of the state is well covered by the cable TV network and Direct to Home Service (DTH) provided by Dish Net, Tata Sky, Doordarshan, AirTel and Reliance. Tamil Nadu State is at the forefront of the country in terms of density of TV networks. We found it a great enabling opportunity to disseminate early warnings to the most vulnerable communities in the state, particularly in the coastal areas. We decided to collaborate with the cable TV operators for display of weather forecast / early warnings during times of disasters and other emergencies. The idea is that the information from the Indian Meteorological Department will be collected by the MIDS (with permission of the District Collector), which in turn will be supplied to local NGOs (our boundary partners). The information will then ultimately be sent to the local cable TV operators for display and telecast. At the moment, we are in the process of negotiating a contract with the local cable operators.

Climatic Variability and Rural-Urban Migration: A Study of Rural Migration to Jaipur City

M. S. Rathore Director
Centre for Environment and Development Studies, Jaipur

Introduction

Climatic variability and widespread overdraft of groundwater resources, coupled with processes of socio-economic transition, are major factors contributing to urbanization in India. Populations in areas affected by water scarcity are adapting by shifting from agricultural to non-farm and urban-based livelihoods. This shift is contributing to the rapid growth of demographic and infrastructure pressures in peri-urban and urban areas. It is particularly evident in regions where long-term groundwater overdraft has depleted the availability of local water supplies for buffering the impacts of climate variability on agriculture. The deteriorating quality of groundwater also poses a threat to health and drinking water security. The situation in Rajasthan State exemplifies the problem. People adapt to the changed situation by moving to urban/peri-urban areas and by shifting livelihoods, which cause new challenges for urban planners and managers of water resources.

With water supplies for urban areas already under severe pressure, the above processes raise major questions regarding the sustainability of sources for meeting the additional domestic water needs and demands. Furthermore, because transitions to urban livelihoods are pulsed (people shift in response to droughts and other similar events) and dynamic (the process isn't one-way), urban water supply needs are difficult to project and many populations remain un-served by municipal systems. The problem is three fold: (1) to project and define the relationship between climatic and water resource conditions on one side and likely population pulses between urban/peri-urban and rural areas on the other side; (2) to ensure clean and safe water supplies are physically available that can meet the changing needs of migrants for domestic and livelihood uses; and (3) to deliver supplies to vulnerable (often transient) populations, particularly in areas that are not served by piped systems. Addressing the above problem in a way that catalyses attention and action requires approaches to research that actively engage key private, public and non-government actors. It also requires evaluation of current policies and projects governing the provision of water supplies to migrant populations. Our overall goal in this project is to undertake a detailed case study of Jaipur city in the state of Rajasthan, India, that documents the interaction between climate, water resources, the wider processes of economic change from migration to urban areas and the growing importance of non-farm, urbanized livelihood systems.

Presently Jaipur city's water supply is largely dependent on groundwater and that is depleting very fast. The rapidly depletion of groundwater is due to over-extraction using pumping technology. The new surface water source, Bisalpur Dam, will be fully operative by the end of year 2009. This source is also planned to meet drinking water demand of many other nearby urban and rural cities/towns and villages. Climate variability will also affect the water availability in the dam and it is likely that the Jaipur city water demand may be not be completely met as per the plans (Rathore 2009).

Jaipur is the only city in Rajasthan with a population greater than 1 million and is the largest city in the state. Amongst all the mega-cities of India, Jaipur ranks 11th with a total population of 2.3 million (in 2001). It is one of the fastest growing mega-cities in the country with an annual average growth rate of 4.5%, compared to the national urban growth rate of 2%.The population of Jaipur city was only 0.3 millions in 1951. From 1971 to 2001, the annual average growth rate has been in the range of 4.1 to 4.7% (Figures 1 and 2).

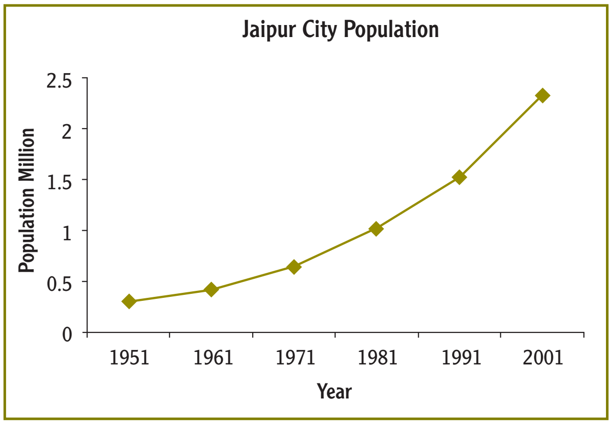

Figure 1

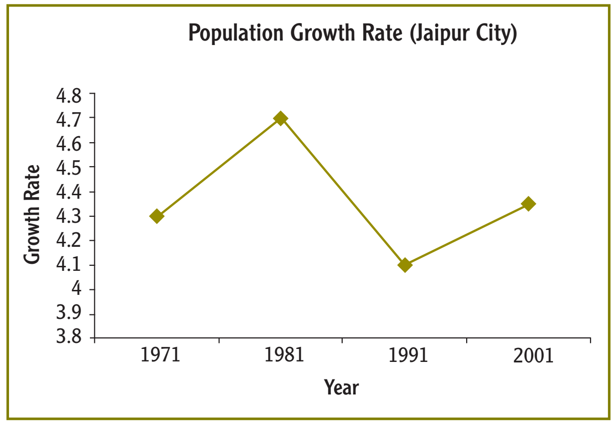

Figure 2

Being the largest city in the state, Jaipur attracts populations from all districts of the state. As per the LEA & CEPT study (2005) the proportion of incoming migrants to the total population of the city in 1991 was 29%, and decreased to 27% in 2001. However, the absolute number of migrants to the city has been increasing and account roughly for around 4 to 6 lakhs[1] . According to the 2001 Census, migrants from various parts of the urban area increased to 53.4% and the share of migrants from rural areas decreased to 46%.This implies that populations from lower order urban centers are migrating to Jaipur for better opportunities. Of the total migrants in 1991 to Jaipur, 70% were from within Rajasthan and 30% from other parts of the country. However, by 2001 the state share decreased by 2%. If the in-migration from Rajasthan is analysed, it shows that nearly 35% migrants in 1991 were from Jaipur district and the remaining 65% from other districts of the state. However, in 2001 the in-district figures decreased by 10% and the outside district figures increased by 10%.The main reasons for migration to the city have been employment and to take advantage of better basic amenities available in the city. About the push[2] factors in the rural areas very little information is available.

Methodology: Village Survey

A survey was conducted to study the impact of climate variability and environmental change, such as the change in frequency and intensity of drought and the depletion of groundwater, on human migration from rural areas to the Jaipur urban area. We want to try to understand the synergies between these factors and how they impact urban water demand. Human migration is governed by a set of social, economic, political, cultural, personal and environmental factors and an attempt was made to identify these factors. Irrespective of caste and class generally people migrate for their livelihood as they see better opportunity to earn outside. But there are some strong social, economic and environmental/natural reasons compelling people to migrate. A multi-stage survey was organised to ascertain the approximate number of migrants, their reasons for migration and to assess the increased present and future urban water demand.The results of this survey will ultimately be used in WEAP model of Jaipur's water supply to create scenario plans for Jaipur City water management through 2030.

The survey was organised in two phases. In the first phase, a survey of labour markets in Jaipur city was conducted. During the second phase, villages were selected from the peri-urban and rural areas in a 100km radius of Jaipur city, which was found to be the catchment area of labour arriving in the city.Two different sets of questionnaires were designed for the survey and were pre-tested.The urban labour markets survey is discussed in a separate brochure.

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1 One lakh is equivalent to 100,000.

2 Push and pull factors refer to the reasons for why people migrate. Push factors include things such as no work or scarcity of water that drive people from their place of origin. Pull factors are things such as higher wages in cities, improved livelihood options, etc.; the enticing factors that draw migrants.

The first survey revealed that migrant labourers come from within a 100km radius of Jaipur City. The survey also helped in identifying the direction and concentration of villages from where the largest numbers of labourers migrate to Jaipur. Based on this information, 18 villages in the radius, in different directions were selected for detailed surveys. In the selected villages, focus group meetings were organised and a sample of 10 migrating households were randomly selected for detailed survey in each village. A questionnaire was prepared and pre-tested for the village surveys. The main objective of this survey was to document the environmental changes in the selected villages, the nature and reasons for migration, the social and economic status of the migrants, status of groundwater and whether the shortage of groundwater is acting as a push factor in rural area, among other question. In total, 180 households were selected for the detailed survey.

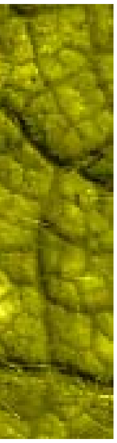
Socio-economic profile of the migrants

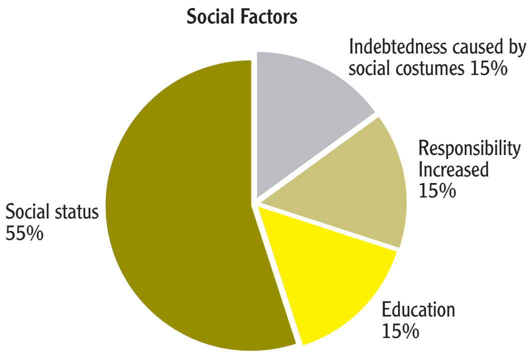
The first step of the survey process required compiling a list of households from which at least one member out-migrated. From this list, 10 households were randomly selected for detailed survey. The most common social category used to analyse rural populations in India is 'caste' grouping. The sample population was grouped into four caste categories: Scheduled Caste (SC), Scheduled Tribe (ST), Other Backward Caste (OBC), and General Castes (all remaining castes commonly called upper caste). The caste composition of sample households was: 22.5% SC, 10% ST, 57.5% OBC, and 10% general caste category households/respondents. The average family size was found to be 8.7 persons per household. The family size varies according to caste category, with SC households having 6.1, ST - 8.0, OBC - 9.6 and General Class 9.8 persons per household. The higher number of members per household in the case of OBC and general class are because of their joint family systems. SC category households are recorded as being comprised of a single family. The dependency ratio was highest among SC households (267) and lowest among ST households (100), and was calculated as the number of earning members divided by the total number of family members* 100. Literacy levels were low among SC and ST households at 22 and 25% of migrants, respectively, reported to be illiterate compared to OBC - 8.7 % and none in general category. The SC and ST were poorer than others, with 22 and 50 % listed as being in the Below Poverty Line (BPL) category. Only 4% of OBC and none of the general category reported as BPL households. Housing condition and amount of land owned were two important indicators of the economic resilience of households. According to these indicators, the economic conditions of SC and ST were much lower than other caste categories. More than 75% of SC and ST respondents had thatched roof houses (*Kachha*) and 83% and 55% respectively owned less than 2 hectares of land. Forty-four percent of SC and 25% of ST households were landless, and as such, had little access to irrigation.

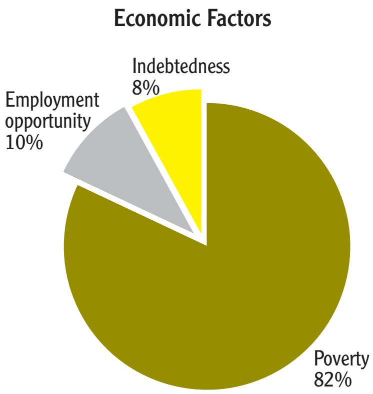
Nature and Reasons of migration

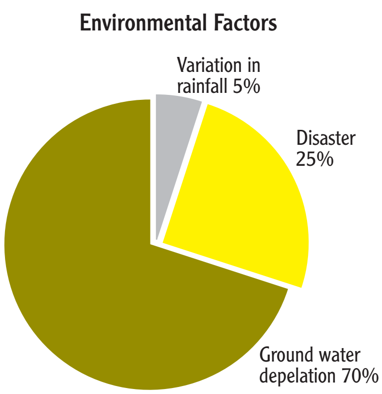
Information was sought on place, nature and practices of migration, reasons of migration, and problems with migration. The place to which one migrates is based upon many considerations including linkages, distance, and past experiences, among others. SC and ST respondents preferred to migrate within their district only, while other caste migrants were willing to migrate to other districts. As SC and ST households either had no land or marginal/small land holdings, they had a specific season or period of migration and would migrate year around. The other caste migrants adopted a pattern of seasonal migration and preferred to normally migrate in Rabi season (winters). In the case of drought and crop failure during the Kharif season (rainy season), migration will occur. Yet, 25 to 30% of migrants from the OBC and general category migrate year around. Female members generally migrate with male members only. The intensity of migration was found to be linked with the agricultural viability in their village area. SC and ST migrants are generally daily commuters, while in the case of other caste migrants only 25 to 30 % were daily commuters. The rest majority of non-SC/ST castes are seasonal migrants.

Social reasons: Maintenance of social status was found to be a major migration push factor with 55% of households having this view in the sample villages. Maintenance of social status was a particularly significant factor of migration reported by more than 70% of OBC and General Caste category of migrants. Indebtedness caused by social expenditures such as, death feasts, marriage or other family functions and increased family responsibility were other social factors inducing SC and ST castes to migrate to Jaipur city. Migration for education of children was reported by only 15% of migrants, but it was a more important factor in the case of ST households compared to other caste categories. Fifty percent of ST households listed this as their reason for out-migration.









Economic Factors: Eighty percent of the respondents hold the view that poverty was the most compelling factor, across all castes, in rural areas forcing them to migrate to urban centres. Better employment opportunities and higher wages bring nearly 10% of the migrants to urban areas. Indebtedness also causes migration and was more a compelling factor in the case of ST households. People were unanimous in expressing that the lack of jobs or work in their village is the single most important economic factor leading to out-migration.

Environmental factors: Disasters such as droughts, floods, fire, variation in rainfall causing crop failure, and groundwater scarcity were the main environmental factors identified by the respondents as contributing to rural out-migration. More than 70% of respondents reported that non-availability or acute scarcity of groundwater for irrigation and drinking were the most compelling factors pushing them out of villages. Except for SC migrants, who are mostly landless labourers or marginal landowners, rapid depletion of groundwater significantly affects the livelihood of Rajasthan's rural population. The situation is further aggravated when there is drought year and both human and livestock populations are forced to migrate from the villages.

Water scarcity and its impact on the livelihoods of the rural populations were separate questions asked to all respondents and was also raised in the village focus group discussions. Ninety-five percent of the sample households expressed that scarcity of drinking water and irrigation water were the most significant push factors responsible for rural-urban migration.

The availability and deteriorating quality of groundwater 100km around Jaipur city, the area from where the migrants arrive, is cause for concern. Drinking water shortages are forcing families to migrate. Seventeen percent of respondents expressed this as one of the causes of their migration. High fluoride content in groundwater is a well-known problem in Rajasthan and 55% of the respondents identified this as a major problem in their villages. With the deepening of wells and tube wells the condition has been further aggravated. Due to the worsening quantity and quality situation, people either purchase tanker water or have switched to using different sources. In the Phagi and Chaksu areas, the groundwater exploitation is less because of saline water.

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Climatic Variability and Rural-Urban Migration: A Study of Urban Migration within Jaipur City

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Introduction

Climatic variability and widespread overdraft of groundwater resources, coupled with processes of socio-economic transition, are major factors contributing to urbanization in India. Populations in areas affected by water scarcity are adapting by shifting from agricultural to non-farm and urban-based livelihoods. This shift is contributing to the rapid growth of demographic and infrastructure pressures in peri-urban and urban areas. It is particularly evident in regions where long-term groundwater overdraft has depleted the availability of local water supplies for buffering the impacts of climate variability on agriculture.The deteriorating quality of groundwater also poses a threat to health and drinking water security.The situation in Rajasthan State exemplifies the problem. People adapt to the changed situation by moving to urban/peri-urban areas and by shifting livelihoods, which cause new challenges for urban planners and managers of water resources.

With water supplies for urban areas already under severe pressure, the above processes raise major questions regarding the sustainability of sources for meeting the additional domestic water needs and demands. Furthermore, because transitions to urban livelihoods are pulsed (people shift in response to droughts and other similar events) and dynamic (the process isn't one-way), urban water supply needs are difficult to project and many populations remain un-served by municipal systems. The problem is three fold: (1) to project and define the relationship between climatic and water resource conditions on one side and likely population pulses between urban/peri-urban and rural areas on the other side; (2) to ensure clean and safe water supplies are physically available that can meet the changing needs of migrants for domestic and livelihood uses; and (3) to deliver supplies to vulnerable (often transient) populations, particularly in areas that are not served by piped systems. Addressing the above problem in a way that catalyses attention and action requires approaches to research that actively engage key private, public and non-government actors. It also requires evaluation of current policies and projects governing the provision of water supplies to migrant populations. Our overall goal in this project is to undertake a detailed case study of Jaipur city in the state of Rajasthan, India, that documents the interaction between climate, water resources, the wider processes of economic change from migration to urban areas and the growing importance of non-farm, urbanized livelihood systems.

Presently Jaipur city's water supply is largely dependent on groundwater and that is depleting very quickly.The new surface water source, Bisalpur Dam, will be fully operative by the end of year 2009.This source is also planned to meet drinking water demand of many other nearby urban and rural cities/towns and villages. Climate variability will affect the water availability in the dam and it is likely that the Jaipur city water demand may be not be completely met as per the plans (Rathore 2009).

Jaipur is the only city in Rajasthan with a population greater than 1 million and is the largest city in the state. Amongst all the mega-cities of India, Jaipur ranks 11th with a total population of 2.3 million (in 2001). It is one of the fastest

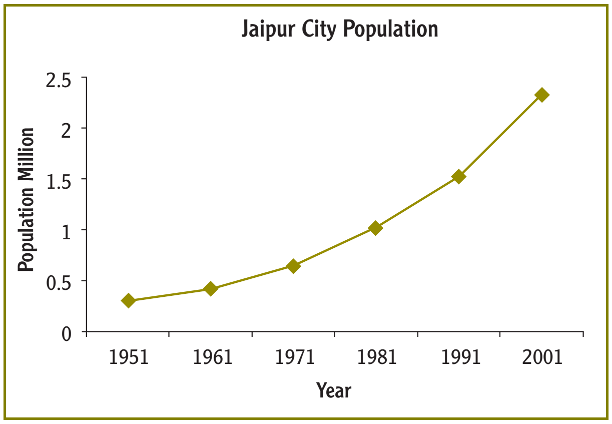


Figure 1

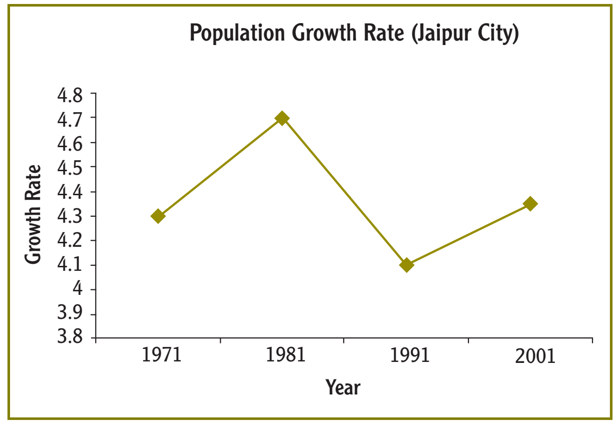


Figure 2

growing mega-cities in the country with an annual average growth rate of 4.5%, compared to the national urban growth rate of 2%.The population of Jaipur city was only 0.3 millions in 1951. From 1971 to 2001, the annual average growth rate was in the range of 4.1 to 4.7% (Figures 1 and 2).

Being the largest city in the state, Jaipur attracts populations from all districts of the state. As per the LEA & CEPT study (2005) the proportion of incoming migrants to the total population of the city in 1991 was 29%, and decreased to 27% in 2001. However, the absolute number of migrants to the city has been increasing and account roughly for around 4 to 6 lakhs[1] . According to the 2001 census, migrants from various parts of the urban area increased to 53.4% and the share of migrants from rural areas decreased to 46%.This implies that populations from lower order urban centers are migrating to Jaipur for better opportunities. Of the total migrants in 1991 to Jaipur, 70% were from within Rajasthan and 30% from other parts of the country. However, by 2001 the state share decreased by 2%. If the in-migration from Rajasthan is analysed, it shows that nearly 35% migrants in 1991 were from Jaipur district and the remaining 65% from other districts of the state. However, in 2001 the in-district figures decreased by 10% and the outside district figures increased by 10%.The main reasons for migration to the city have been employment and to take advantage of better basic amenities available in the city. About the push[2] factors in the rural areas very little information is available.

Methodology

A survey was conducted to study the impact of climate variability and environmental change, such as the change in frequency and intensity of drought and the depletion of groundwater, on human migration from rural areas to the Jaipur urban area. We want to try to understand the synergies between these factors and how they impact urban water demand.The rapidly depletion of groundwater is due to over-extraction using pumping technology. A multi-stage survey was organised to ascertain the approximate number of migrants, their reasons for migration and to assess the increased present and future urban water demand.The results of this survey will ultimately be used in a WEAP model of Jaipur's water supply to create scenario plans for Jaipur City water management through 2030.

The survey was organised in two phases. In the first phase, a survey of labour markets in Jaipur city was conducted. During the second phase, villages were selected from the peri-urban and rural areas in a 100km radius of Jaipur city, which was found to be the catchment area of labour arriving in the city.Two different sets of questionnaires were designed for the survey and were pre-tested.

[1] One lakh is equivalent to 100,000.

[2] Push and pull factors refer to the reasons for why people migrate. *Push* factors include things such as no work or scarcity of water that drive people from their place of origin. *Pull* factors are things such as higher wages in cities, improved livelihood options, etc.; the enticing factors that draw migrants.

Labour Markets Survey: Forty-six labour markets were identified in Jaipur.These markets are locally known as 'Chokti' and they are scattered all over the city, mainly along the main roads and rail routes entering the city. Every morning around 8 am, labourers (skilled and unskilled) assemble at these markets and wait for customers to hire them. In case one fails to get job, he/she waits until 11 am before going home and returns back next day.The number of labourer in a Chokti varies between 500 to 2500 individuals.The number also varies seasonally or on festival days. During the monsoon season, low numbers of labourers were observed. Labourers who become attached to contractors do not go to the labour market; rather they directly report to the work site, and make up a significant portion of migrants.

A questionnaire was prepared and pre-tested for the survey of these markets. All the 46 markets were visited and out of these, 10 labour markets were purposely selected to ensure a geographical distribution covering all the entry points to the city and on the importance of the market. In the selected markets, focus group discussions were organised and 10 sample labourers were selected for detailed investigations.The principal survey themes investigated the nature of migration, including: causes or reasons for migration, duration of migration period, housing within the city, and facilities and problems at the market, particularly concerning the provision of basic amenities such as drinking water, sanitation, food and transportation.The results of the first survey were used in the planning of second survey.The second survey conducted at the village level is described in a separate brochure.

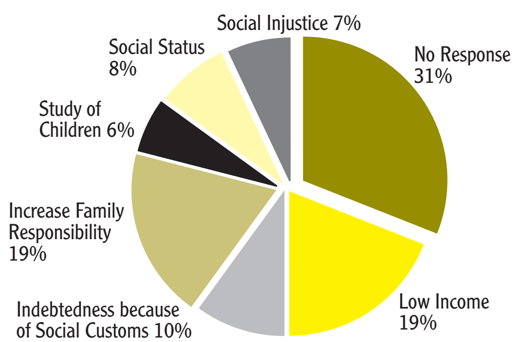
Survey results

The survey of labourers in Jaipur City assembling at the Choktis had two main parts.The first focused on the social and economic profiles of the labourers and the second part, on details of their migration and labour market problems.The survey revealed that 25 % of the sample labourers were illiterate, 61% had an education up to Middle, 12% up to higher secondary and only 2% had a graduate degree. In terms of their economic status, only 21% were from Below Poverty Line (BPL) households. None of the labourers had any formal skills training. Most labourers acquired skills either through their traditional family occupation or learning by doing.The sample labourers were asked about the duration they have been migrating. It was interesting to uncover that 54% reported that they have been migrating the last five years, 26% the last 6 to 10 years and 20 % more than 10 years.The labourers were also asked about their native places. It was observed that 36% of males and 71% of females migrated from within Jaipur district. Fifty-five percent of males and 26% of females were from other districts within Rajasthan. Only 9% of males and 3% of females reported to have come from other States.

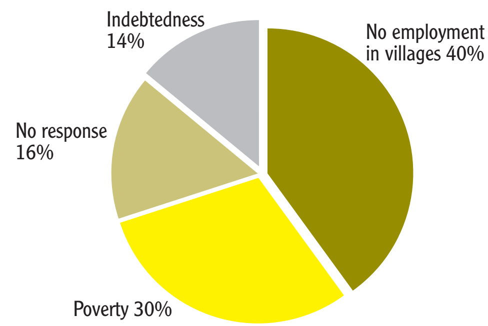
Nature of migration:The migrants were asked about the nature of their migration, that is, whether they are daily commuters, seasonal migrants, or stay for longer periods. Information was also collected on lodging accommodations of the Chokhati labourers. Daily commuters accounted for only 14%, while seasonal and longer stays were reported by 36 and 50% of the labourers. Male and female labourers had different patterns of migration, as 56% of males reported less than three months as their period of stay compared to 81% of females. Male labour had a higher percentage of longer stays (9 to 12 months) than females, the percentages were 21 and 7% respectively. Seventy percent of labourers reported renting accommodations and only 3% had arrangements with their relatives.The payment for the rented space varied between Rs. 500 to 1100 and 67% reported paying between Rs. 500 to 800.

Reasons for migration: Human mobility is governed by a set of social, economic, political, cultural, personal and environmental factors. Detailed information was collected in the focus group discussions and from sample labourers about the reasons for their migration to Jaipur city.The reasons given were classified into four broad categories: social, economic, environmental and others.The main social causes leading to migration reported by 57% of the respondents were: low income due to a breakdown of the jajmani system (a traditional system of inter-linkages among the different castes, mainly the ruler caste and the rest.Village artisans and other caste people used to provide household and other services and in lieu of the services, they used to receive in-kind payment twice in a year at the time of seasonal crop harvests), village artisans are no longer receiving the traditional support from the society, indebtedness caused by social systems of death feasts, marriages and other customs, increased social responsibility as either being the eldest in family and/or the sole earning member, and to maintain their social status in the village, etc. Migration for acquiring an education in urban areas was reported only by 6% of the labourers. Iniquitous distribution of ancestral property forced 7% of respondents to end up in the urban labour market.The prevailing unemployment in the rural areas as factor leading to rural-urban migration was reported by 40% of the respondents.Thirty percent and 14% of the labourers, respectively, reported poverty and indebtedness.

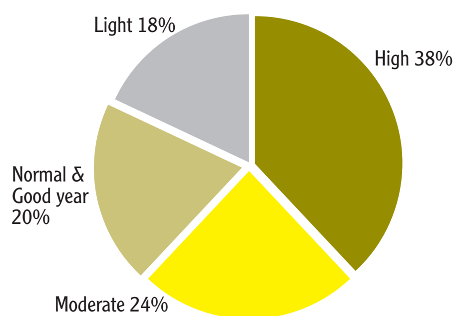
Social Reasons



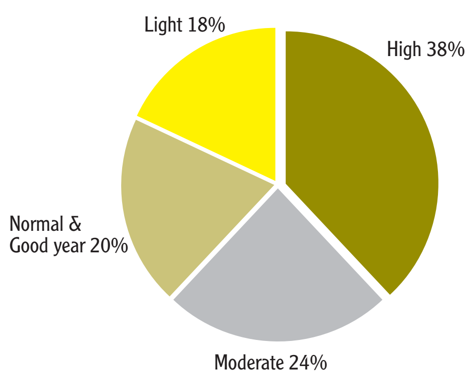
Economic Reasons



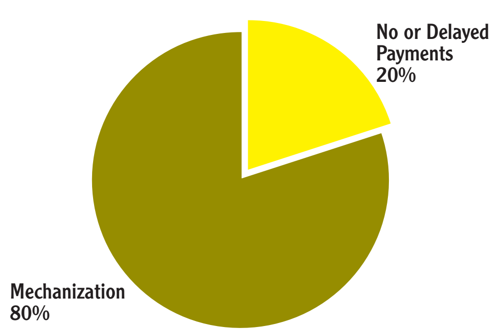
Environmental Factors



Intensity of Drought and Migration



Other Reasons



Type of work in Urban Areas: Sample respondents were asked to report about the type of work they find in the urban centre. Chokhati labourers reported finding work in three main areas, namely, construction, mechanical and the service sectors.The construction sector engages 76% of labourers, followed by mechanical work 14% and the service sector 7%. In the construction industry, both skilled and unskilled workers are engaged, while in mechanical work only skilled workers are engaged. Skilled work reported included plumbing, marble cutting, painting, etc.Tractor driving constituted the main service sector activity, as tractors are the main mode of transport for building material supply and water supply.

Employment situation in Urban Areas: The labourers at the Chokti were asked to describe the condition of labour market in terms of getting employment, basic amenities such as drinking water, shelter, food and wages. Almost all labourers reported difficulty in finding daily employment. It emerged from the survey that 89% of labourers reporting at the Chokti find employment for 10 to 20 days a month, and only 11% find more than 20 days a month.The main reasons given were more labour supply than demand (90%) and mechanization leading to demand for skilled labour (8%).The wage rate varied between Rs. 120 to 350, and it is lower for women. Of the sampled labourers, 47% reported getting wages between Rs. 120 to 150, 52% receive between Rs. 150 to 250 and only 1% earned more than Rs. 250.These wages equate to a monthly income ranging between Rs. 1800 to 6500. With regard to the facilities at these labour markets, 23% of the respondents were not satisfied with the water, food or shelter.The quality and quantity of water supply at the market was reported to be unsatisfactory. However, the municipal corporation of Jaipur is beginning to take the initiative to build facilities at these markets and few have already been upgraded.

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Assessing Options for Climate-Resilient Urban Water Management: Use of WEAP as an Assessment Tool in Jaipur City, India

CEDSJ and ISET

The Context

Managing water supply in urban areas is increasingly challenged by growing urban populations and problems of quality, allocation, equity, and resource sustainability. With climate change (CC) likely to manifest in the form of increased variability at multiple timescales and increases in the frequency and intensity of extreme events, water management problems will be further compounded. It is striking to note that while on one hand, CC impacts resource availability, it also intensifies demand on water resources by triggering an increase in rural–to-urban migrant population, as rural populations find that agriculture is no longer feasible and must move to urban areas to find employment. However, there is very little knowledge as to what extent the migrant population might increase or decrease in the future, especially due to CC.

Conventionally, the increasing demand for water supply to urban areas in India is met by augmenting supply sources with very little attention paid to increasing use efficiency or to managing urban sprawl in a planned manner. This has resulted in a shift in supply sources, generally from surface water reservoirs, to a more distant source.

The current project being implemented by ISET in partnership with CEDSJ (Centre for Environment and Development Studies, Jaipur, India) and supported by the National Oceanic and Atmospheric Administration (NOAA – United States), assesses the dynamic interaction between CC, water resources and larger processes of socio-economic transition of migration in Jaipur city; the capital of Rajasthan. Rajasthan is one of the most arid states of the country. The evaluation of Jaipur's water supply, both current and projected, is carried out through the following steps:

- Downscaling climate change projections from two AR4 general circulation models to determine possible precipitation changes under the SRES A2 and B1 scenarios for the Banas River Basin;
- Developing a model of Jaipur city's water supply and demand using the Water Evaluation And Planning (WEAP) software developed by the Stockholm Environment Institute's U.S. Center
- Linking these two aspects with current and extrapolated future migration patterns that affect/are likely to affect water demand for Jaipur city.

This paper presents the approach for WEAP modeling. Through downscaled precipitation projections from two GCMs, and via the process of SLDs (Shared Learning Dialogues), the project will inform water planners and managers, other key stakeholders of Jaipur city, and Rajasthan state.

Jaipur is the largest city of the State of Rajasthan with a total population of 2.43 million (as per 2001 census). Jaipur city's population has been rapidly increasing at an annual average growth rate of 4.5%, against a national urban growth of 2%. The city is a major hub for migrant population from the state. More information about the migration dynamics to Jaipur is detailed in the briefs: Climatic Variability and Rural-Urban Migration: A Study of Rural Migration to Jaipur City and Climatic Variability and Rural-Urban Migration: A Study of Urban Migration within Jaipur City.

After a decline of inflows to Ramgarh Lake, Bisalpur Dam is currently the major (surface water supply) source for Jaipur city. Groundwater extraction continues to meet the gap between demand and supply from the reservoirs. A number of industrial estates have built up around Jaipur, exerting pressure on the already fragile water resources in the area. Additionally, a number of rural areas around Jaipur have transformed into peri-urban areas that also depend on Bisalpur Dam for water supply. Already, demand on Bisalpur Dam exceeds natural inflows to the reservoir.

The WEAP Model

The WEAP model is an integrated tool for water balance accounting developed by SEI and, specifically in the context of the project, achieved by simulating a typical urban water system, that of Jaipur India. It places demand side equations —water use patterns, efficiency of uses, allocation priority—on equal footing with the supply side—streamflow, groundwater, reservoirs, etc. The strength of WEAP is in its ability to provide the user with the flexibility to define demand and supply on a per use basis, and to define the drivers influencing these uses, such as scale and efficiency levels, population, technologies of water use and allocation priorities. With its ease of use and modularity, WEAP helps evaluate and compare alternative water development and management strategies. The program can also be used to generate a database of water supply and demand systems. As a forecasting tool, it helps project supplies and demand patterns. This forecasting dimension of WEAP is particularly useful when simulating climate change (CC) impacts on water resource systems. The primary way that WEAP is used entails the construction of two models: a) generation of a business-as-usual scenario also known as a reference account; and, b) generation of scenario cases that build on the reference account with changes in future projections with regard to supplies, for instance; due to CC and water demand and/or due to an increase in floating populations because of migration—a phenomenon partially triggered by the impacts of CC.

Approach to Setting Up WEAP for Jaipur

For the purpose of modeling, the base account for the year 1991 was developed using the data and parameters of that year with the following key considerations:

- The level of industrial, demographic and water resources development;
- Water use efficiency in various sectors—industrial and domestic; and,
- The level of supply and storage characteristics of local groundwater sources and the reservoir (Ramgarh Lake).

The business-as-usual scenario (or reference account) was developed for 1991-2035 using the projected/ planned growth rates and trends of population, industrialization and water resources development. Since Bisalpur Dam is expected to be operational sometime during 2009, it was modeled to function from 2009 in the reference account.

Hydrology was modeled through the following four steps to generate monthly flows for the modeling period:

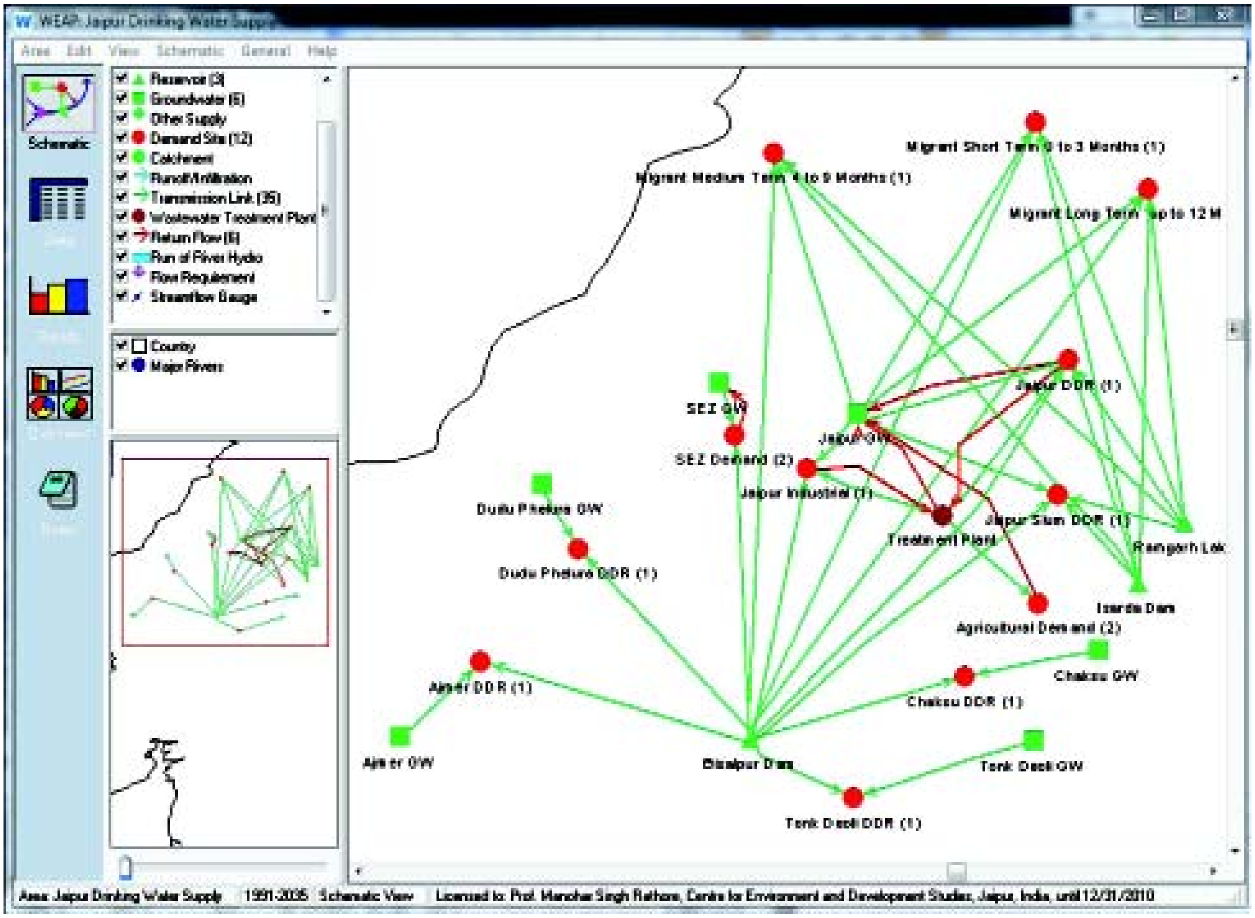
- The historical, yearly time-series of rainfall was used to categorise years across five water-year types based on deviation of mean annual rainfall—very wet, wet, normal, dry and very dry;
- Averages of rainfall for various months by water-year types were computed;
- Considering the simulated yearly time-series of monthly runoff values of the Banas River Basin with monthly rainfall, a rainfall-runoff coefficient for each water-year type was computed.
- The time-series of future water-year type from 2009 to 2035 is projected via climate downscaling for the basin. The downscaling methodology being employed in this study is described in the brief Projecting Climate Change Impacts on Smaller Geographic Scales: Downscaling to the Rohini Basin, Nepal, which was piloted in a previous project by ISET.
- The precipitation projection outputs are then used in assigning water-year type values (out of the five categories per above) to each of the modeled years.

The core approach is, however, to consider all demand sites, including urban, rural domestic and industrial uses, in a contiguous geographical area spanning across blocks and districts that draw water from the main surface water reservoir that supplies water to Jaipur city. Hence, the supply service areas of both the Ramgarh and Bisalpur dams were considered. This approach would be enable the model to produce the following:

- Changes in rural *vs.* Jaipur city's urban water demand in that contiguous geographical area;
- Assess level of competition for the resource across these areas as CC manifests, thus triggering socio-economic transition; and,
- Increase in Jaipur city's water demand specifically due to changes in migrant population.

Data and Assumptions for the Jaipur Model

The screenshot WEAP schematic for modeling water resources for Jaipur city is as shown below:



Demand Sites

In line with the approach described in the foregoing, the following demand sites were modeled to represent all water uses in the contiguous geographical area:

- Five domestic water demand sites for:
  - Jaipur DDR: Covering the area of Jaipur, Amber, Sanganer, and Phagi Tehsils.
  - Dudu-Phulera DDR: Covering the area of Malpura, Dudu and Sâmbhar Tehsils.
  - Chaksu DDR: Covering the area of Todaraisingh, Peeplu, Newai, and Chaksu Tehsils.
  - Tonk Deoli DDR: Covering the areas of Tonk, Deoli, and Uniara Tehsils.
  - Ajmer-Bewar DDR: Covering the area of Kekari, Sarwar, Ajmer, Nasirabad, Bewar, and Kishangarh Tehsils.

- Two industrial demand sites for recently developed SEZ and Jaipur industrial area;
- Two demand sites for Jaipur city: one excluding the slum populations and one including the Jaipur slum populations; and,
- Three demands sites for migrant population types—short-term (up to 3 months), medium-term (up to 9 months) and long-term (up to 12 months).The migration population types and their determination are covered in separate brochures.

Data for drivers of demand

Population for each demand node:The population at each demand node was derived from a variety of sources, including the Census of India 1991 and 2001 as reported in the District Statistical Handbook (DSH), published by the Directorate of Economics and Statistics and the Government of Rajasthan, Jaipur. As mentioned in the five drinking water demand nodes above, these demand nodes were created based on the supply of water from Bisalpur dam to different rural and urban areas.The total population for each demand node is calculated by adding the coverage area population. In a few cases, the main water line also passes through the area.

Slum population:The number of people living in the slum areas is taken from the Census of India 1991, 2001 reports.

Migrant population:The source of data is from the report entitled "Migrant Worker in the Construction Sector-A Study in the Chowktis of Jaipur", PUCL, July 2002, pp.53-62.The data were also drawn from the special migration surveys administered under this project for Jaipur city in the year 2009 and described in separate brochures.

Livestock Population: Livestock census, Department of Animal Husbandry, Government of Rajasthan and as published in DHS, GOR.

The **growth rate of the populations** of both human and livestock is based on the decadal growth rate as projected by the Census of India based on district-wise decadal population since 1951.

Annual water use rate:The Government of Rajasthan norms for rural and urban water supply are 80 litres per capita day (lpcd) for Jaipur, 60 lpcd for Ajmer and the remaining rural areas are alloted 40 lpcd.These values were taken from the report entitled "City Development Plan for Jaipur City", section 9.6: 'Existing and future demand gaps in core urban services', pp 9-34, LEA Associates South Asia Ltd., New Delhi *in association with* CEPT, Ahmedabad.

Water supply losses: The water distribution losses for Jaipur City were cited at 44% as reported in the report entitled "City Development Plan for Jaipur City", Section: 9.6. 'Existing and future demand gaps in core urban services', pp. 9-34, LEA Associates South Asia Ltd, New Delhi *in association with* CEPT, Ahmedabad.

Priority: As per national and state water policy documents, drinking water is listed as the top/ first priority and we have also adopted this as the top priority water usage in the model.

Data for hydrology

Rainfall data are taken from the report entitled "Rainfall in Rajasthan: 1960 to 2001", published by the Statistical Cell, Department of Agriculture, Pant Krishi Bhawan, Jaipur, and data for the years 2002 to 2006 are taken from the report 'Mansoon-2006', Government of Rajasthan, Water Resource Department, Jaipur.The year-wise time series of rainfall data is classified into five types of water years based on the percent deviation of that year's rainfall from the mean rainfall and put into categories as follows:

Water Year Type Classification (percent deviation):

1. **Normal** (+5 to -5)
2. **Dry** (-5.01 to -25.0)
3. **Very dry** (>- 25)
4. **Wet** (+5.01 to +25.0)
5. **Very wet** (> +25.00)

Natural Recharge: As more than 80% of annual precipitation takes place during the monsoon months of July, August, September and October.The annual recharge is divided into four months August-November, allowing for an assumed one month lagtime in recharge.This one month lag is due to the model running on a monthly timestep, which does not allow for more nuanced flow modeling.

Flow: Simulated flows are measured in units of million cubic meters. Simulated flows for the entire Banas River for the years 1960 to 1993 were taken from the Report ofTAHAL – WAPCOS Consultants entitled "Water Resource Planning for the State of Rajasthan".

Data for Supply nodes

Surface water source: Only one surface water source, namely Bisalpur Dam is considered as other surface sources are negligible and the city is planning to supply the majority of its demand from the dam.The details of the source are as follows:

Local Reservoirs: Bisalpur Dam: Information on dam storage capacity, initial storage, operations, etc., are taken from the report "The salient features of Bisalpur Dam".The information on net evaporation losses, losses to groundwater and the volume elevation curve are taken from the "Bisalpur Project Report 1991",Volume-1, General Report, pp. 5-20,Table-6.

Groundwater:The groundwater supply data is taken from the "Report on Dynamic Groundwater Resource of Rajasthan", published by the Central Ground Water Board, Government of India (GOI), Jaipur and the Groundwater Department and the Government of Rajasthan (GOR), Jaipur. Rajasthan is divided into 237 groundwater blocks and data is reported for 236 blocks. For our model, relevant block-wise data was added for the different supply nodes reported below.

Each groundwater supply node covers the following blocks:
Jaipur: Amber, Jhotwara and Phagi blocks
Dudu-Phulera: Phulera, Dudu, & Sambhar blocks
Chaksu: Chaksu, Newai, andTodaraisingh blocks
Tonk –Deoli: Deoli,Tonk, and Unira block
Ajmer-Bewar: Arain, Bhinai, Kekari, Masuda, Silora, and Srinagar blocks
SEZ: Sanganer block

Storage capacity:The maximum theoretical capacity of the known and mapped aquifers is considered as storage capacity.

Initial storage:The amount of water stored in the aquifers at beginning of the simulation.

Maximum withdrawal:The assumed monthly maximum that can be withdrawn from any single aquifer.

Linking demands:The present and future year capacities of transmission links to supply surface water from Bisalpur Dam were taken from the report "BWSP Final Bid Document" June 2006\BWSPVolume 2, Employer's Requirements (with addendum).

Alternative scenarios through WEAP modeling

Having set up the reference account for modeling Jaipur's water supply management in WEAP, the following scenarios have been developed to assess gaps between demand and supply for Jaipur city:

Supply augmentation scenario (combination of following):

- What if 20% of houses in Jaipur city (assume 100,000) adopt rainwater harvesting with an average rooftop area of 400 sqm?
- What if another surface water reservoir project with 70% capacity of Bisalpur is added by 2020?
- What if artificial recharge techniques are implemented to replenish the groundwater system in the area?

Demand management scenario:

- What if wastewater from the Sanganer treatment plant is reused in agriculture (50%), industry (30%) and the rest for meeting Jaipur urban non-drinking demand?
- What if the transmission losses are reduced from 44% to 25%?

Integrated scenarios: Combinations of above scenarios

Remaining Work

The WEAP model has been setup to evaluate the scenarios. The strength of WEAP is its transparency to assumptions and its provision on flexibility to change the assumptions and re-evaluate various scenarios. In next few months, we plan to undertake:

- Downscaling large-scale climate information from two GCMs (CGCM3 and ECHAM5) to generate rainfall projections for 2009-2035 under the SRES A2 and B1 scenarios for the Banas River Basin;
- Feed the rainfall projection scenarios into WEAP and assess the synergies between the future demand scenarios and the rainfall projections;
- Ratify the approach and assumptions to modeling WEAP through Shared Learning Dialogues (SLDs) in order to facilitate the process of deeper engagement with key stakeholders; and,
- Generate and compare scenarios on adaptive urban water management.

The results of this study will be shared with key stakeholders and, hopefully, open dialogue to consider more holistic water management.

Towards Building Climate-Resilience in Surat City: Asian Cities Climate Change Resilience Network (ACCCRN)

ISET and TARU Leading Edge

The Purpose

Shared Learning Dialogues (SLDs) are processes of structured consultations with key agencies, groups, organizations and the community. They are useful for scoping (spatial, temporal, socio-economic and thematic—such as water and energy) and understanding factors shaping vulnerability and adaptation options. Specifically in urban contexts, the SLD process needs to be augmented, preferably by GIS enabled vulnerability analysis, field survey and specialised sectoral studies in order to develop a comprehensive understanding of systemic factors and the interlinkages between those factors that influence vulnerability to climate change. While SLDs assist in providing a quick snapshot of the range of vulnerability issues, they also help build views on related issues among stakeholders, thus facilitating deeper engagement.

This paper described the process of SLDs to date, implemented in Surat City, India as part of the Asian Cities Climate Change Resilience Network (ACCCRN) project being implemented in three Indian cities: Surat, Indore and Gorakhpur. ACCCRN aims to catalyse attention, funding and action on building climate change resilience for poor and vulnerable communities. ACCCRN aims to accomplish these goals by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of various partner cities. More information on the ACCCRN project can be found in the ACCCRN brochure.

The City Context

Surat, a "born-again city[1]", located on the River Tapi is India's ninth largest and Gujarat State's (western India) second most populous city, with a population of 2.4 million (Census 2001). Since the inception of SUDA (Surat Urban Development Authority) in the late 70s, the city has been growing at a rapid pace. In the last four decades, Surat's population has increased 10 fold (Surat City Development Plan 2006-2012).

Surat is a trade and industrial centre including textile manufacturing/trading, as well as diamond cutting and polishing. In addition, there are chemical, petrochemical and natural gas based industries in Hazira (a major Indian port located near the city of Surat and under its jurisdiction). Surat is a pivotal centre on the Ahmedabad-Mumbai regional corridor and also has direct linkages with the industrial urban centres of Vadodara, Ankleshwar and Vapi.

[1] Poor infrastructure and minimal waste management contributed to flooding in the city in 1994, which led to a plague epidemic in the city. After this event, Surat worked hard to improve waste management, infrastructure and services to most of its citizens, in this sense completely revamping city life and identity.

The Surat Municipal Corporation (SMC) is able to supply water to about 97% of its total area and 95% of its population, the main source being RiverTapi. At present, a gross of 195 litres per capita per day (lpcd) is being supplied in the city. For areas outside the municipal corporation (SUDA area), there is no systematic water supply system.The main sources of water in these areas are a water supply scheme implemented by GWSSB (Gujarat Water Supply and Sewerage Board) and tube wells (Surat CDP).There has been a rapid increase in the sewerage network in the recent years, as a result of which 92% of the city's area is covered.The city already has 6 sewage treatment plants, one for each zone of the city.

The city has undergone a sea of change in its practice of solid waste management since the plague hit the city in 1994. Currently, the city has a collection efficiency of 98%. While there are no scientific methods of disposal as of yet, construction of treatments plants is underway. After the plague epidemic, surface drains were constructed in all the slums and are being cleaned every week.

According to the CDP, there are 312 slums in the city.There is a high migration rate in the city due to ample employment opportunities available in the city. Almost 70% of the total hutments (hut encampments) in the slum areas are catered through a piped water supply network, leaving the remaining hutments to be served either by stand posts or tankers. By 1996, SMC had paved 75% of the internal roads in the slums with Kota stone.The municipality sweepers clean these roads everyday. In 1995, SMC had launched the construction of community toilets and to date, 136 such complexes have been constructed. Around 48 slum pockets were covered under the National Slum Development Programme.

Possible Climate Change Impacts

Climate projections loosely scaled from a single general circulation model, the Canadian Third Generation Coupled Climate Model (CGCM3) indicates that precipitation is likely to increase in the region by about 50 to 100 mm, along with an increase in climate variability. More regionally specific, downscaled climate projections for Surat have not been found by the time of this publication and the above precipitation projection is based on a simple scaling exercise conducted by ISET (Opitz-Stapleton et al. 2009). Since outputs from only one GCM were utilized, no statements can be made about the uncertainty (range) in the projection.There is limited agreement amongst the GCMs summarized in the latest IPCC (2007) report on precipitation projections for South Asia, other than that monsoon precipitation might intensify. Additionally, general IPCC (2007) projections indicate that an increase in the frequency of extreme rainfall events is possible for the South Asia region. Thus, if monsoon precipitation amounts increase, particularly if falling during extreme rainfall events, flood risk in Surat is likely to increase over the next few decades.The floods in the year 2006 covered almost the entire city and affected nearly 75 percent of the population. Currently, flooding risks faced by the city are twofold:

1. Flooding due to overflow of the river (and release of water from Ukai); this was the reason for the 2006 floods.
2. Local inundation and high tide

The other major risk that the city faces is sea level rise. Surat is located about 15 km from the coast and the altitude is less than 13 m above mean sea level. Even with a sea level rise of one meter, areas currently beneath the high tide zone will be impacted, which includes the western parts of the city.This danger is also borne out by anecdotal evidence. One of the highest known tides was reported in 2008 in the adjoining region of Dumas, which inundated many roads in western parts of the city.

The Shared Learning Dialogue (SLD) process

The SLD process in Surat has been somewhat different than in other cities, primarily due to the excellent response received from various city actors. Both the SMC and the South Gujarat Chambers of Commerce and Industries (SGGCI) have been enthusiastic partners from the very first meeting. More information about the SLD methodology can be found in other briefs in this series.

During the 1st round of SLDs[2] , followed by visits within the city and slums, the following key findings related to Surat emerged:

[2] In the wake of the election code of conduct during the run-up to national elections in early 2009, meetings with more than one or two actors with government backgrounds could not be organized. So as an alternative, we resorted to holding one-to-one meetings with various key actors.

- A good network of organizations (SGCCI, Industrial Associations, SEWA Setu) exists;
- Experience in handling disasters incorporating synergies across sectors. For example, when the 2008 floods occurred in Bihar, SGCCI mobilised goods worth Rs. 5 crores, as well as during 2006 Surat floods. SMC, Civil Society and industry linkages have been well established there also;
- Industry groups the city into three divisions—diamond, textiles and Hazira; it operates at different levels and is seen as a challenge to integrate.There are 6-7 industry clusters within Surat.The textile industry is the largest with more than 1 million of the population involved in it.There are three sub-types within the textile industry, namely processing units (>600), weaving units (> 6 lakh) and textile engineering units.The diamond industry is the second largest with a population of about 8 lakh dependent on it;
- A Disaster Management Plan (DMP) for the city exists, which was driven by UNDP, however looking at the new challenges due to climate change, there is a need to revise the DMP;
- The Surat Municipal Corporation reported that nearly 85 percent of the slums have most of the basic services such as, water supply, electricity, and to some extent sanitation.There are also plans for further rehabilitation and relocation of some of the slums.
- The sewerage system is plagued by a number of problems, such as; a low number of sewerage connections, ingress of storm water drainage and solid waste flow into the sewers, and old/dilapidated sewers in some parts of the city. However, SMC claims that post-plague (1994) the *nala* (*khad* or drains) cleaning is done regularly every year before monsoons, but some of the areas visited during transect walks for the GIS-enabled vulnerability analysis do not show signs of such practices.
- Various typologies of floods are noted: khadi floods which are pluvial floods (influenced by local rainfall, often exacerbated by high tides);Tapi floods driven by tropical depressions moving westwards and emergency releases from Ukai dam. Due to Surat's location (on banks of theTapi River, near the estuary of the Arabian Sea) and its flat topography, the land drainage in Surat is relatively poor. In the past during the monsoon months, many areas of the city experienced temporary flooding and blockage of storm waters due to overwhelmed storm drains;
- The High Flood Level (HFL) of 2006 (8th and 9th Aug) is marked all over the city.This information is useful to assess potential damage for current and future projections;
- Early signs of competition over water use were noted: urban (industry and domestic) vs. agriculture that may potentially be exacerbated in the future due to climate change and demand, along with an increase in salinity;
- Similarly, competition over power/electricity has also begun. People living in one of the slums visited (Limbayat) mentioned that one day per week they do not have electricity. It was reported that similar 'planned load-shedding' is done in other areas too. More investigation is needed to ascertain the power situation in the city with the increasing industrialization.

As noted earlier, the receptiveness from the city actors to the ACCCRN project was so good that the City Advisory Committee (CAC) was formed in the 2nd round of discussions with SMC and SGCCI.The 2nd round of consultations entailed in-depth discussions on ways that the development issues will be exacerbated due to climate change impacts. Both SMC and SGCCI came fully on board and started the process of initiating and driving the project activities. Key persons from various walks of the city were identified/ nominated for being part of the CAC.This round was held with SUDA, SMC, SGCCI, large industries like Shell,TORRENT Power, GIDC, Electricity Distribution Company, irrigation department, etc.

The 3rd round of SLDs were held with the City Advisory Committee along with the line-departments of SMC.The main focus of this meeting was to scope out sectoral studies needed to develop a comprehensive understanding of various facets of urban vulnerability.The Municipal Commissioner appreciated the need to identify areas for sectoral studies, while capturing the vulnerability of the city with respect to flooding, seawater ingress, risks to health and risks to the economy (loss of person-days, loss of assets, loss of income, and decrease in the earning capacity of the people, etc). The importance of inter-sectoral linkages was brought forth especially in the present scenario, for example, impact on transport sector due to the growing urban energy need, which in itself is becoming scarcer in terms of cost-effectiveness.The following sectors were identified in this meeting:

S. No.	Sectors	Responsible Department/ Organization
1	Water Security	SMC
2	Flood Risk Management	Centre for Social Studies
3	Health Impact	Govt Medical College, Surat
4	Energy Security	SGCCI
5	Environment - Clean Air	TIFAC
6	Awareness Generation	SES
7	Climate watch Group	Luthra Dyeing and Printing

Following the meeting, the sub-groups were provided with a framework on which the proposal for the sectoral study was to be developed. It was decided that each sub-group would develop a core concept proposal note within a week so it could be finalised for drafting ToRs in the next CAC.

The following round of discussions was carried out with each sectoral study sub-group following the receipt of their proposals. These meetings focused on the specific proposal and discussions centered on issues of methodology, data availability and gaps, and the need for external support/ expertise. This expertise could be sourced out to TARU/ISET or other departments/ organizations within the city. These meetings culminated with a meeting of the CAC, where the proposals developed by each sub-group were presented and discussed. This meeting also presented an opportunity for identification and establishing cross-linkages between the sectoral studies and the data needs.

Table 1: Impact of Micro Irrigation Technologies on Crop (applied) Water Productivity on Selected Crops in North Gujarat

Level of Consultation	Key Persons/Groups	Key Outputs	Time Period
First level (1-on-1)	SGCCI, SMC, Industrialist, Slum Community	Major issues and problems faced by citizens in the city	Dec 2008
Second level (specific groups)	SMC, Water Supply Department, IDA, Hotels, Educational Institutions, Industry associations, Pvt Tankers Association, Community Associations	Deeper understanding of the issues identified during the first rounds and identification of key persons for the inclusion as members of City Advisory Committee	April 2009
Third level (City Advisory Committee)	Key persons identified for their interest in the project	Sub groups for specific sectors formed, possible sectoral studies identified	June 2009
Fourth level (Sectoral study sub groups and CAC)	Discussions on the specific sectoral studies and the outputs expected	Sectoral studies finalised and deadlines fixed for reports	July 2009

Ways forward

After the three rounds of consultations and meetings of various sub-groups identified for undertaking sectoral studies, the plan was to hold the next round of consultations (SLDs) after the completion of the city-wide vulnerability survey (for details refer to the brief GIS Enabled Urban Risk and vulnerability Analysis: Indore and Surat for the ACCCRN Project) and the sectoral studies. The enthusiasm among city level agencies and organizations demonstrates the high level of buy-in on the project. It is also noteworthy that the city level agencies and organizations took interest in driving the whole process for assessing vulnerability and identifying adaptations options that would lead to developing a city-resilience plan.

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Ecosystem Management and Adaptation Impementation

Winrock International India, ISET
and
ISET - Nepal, GEAG, UTTHAN and MIDS,
Sara Ahmed and Daanish Mustafa

The Context of Adaptive Ecosystem Management

Human wellbeing depends on the capacity of the earth's natural systems to provide ecosystem goods and services. Ecosystems not only provision food, freshwater, fuel-wood and genetic resources, but also help in regulating, and mitigating the impacts of climate manifested through inter-annual variability of rainfall and extreme events such as floods, droughts and cyclones. Healthy ecosystems and vibrant ecosystem services will become increasingly important in supporting adaptation as the climate becomes less predictable due to anthropogenically induced climate change. The Millennium Ecosystem Assessment (2005) alarmingly concludes that, unless we take action to mitigate the decline in ecosystem services, the costs to society will be substantial. One of the goals (number 7) of the Millennium Development Goals is 'environmental sustainability'.The challenge to achieve these goals in a changing climate regime will be even greater.While a number of measures need to be taken at the national and global levels, at the local level, sustainable management of environmental resources will support adaptive capacity and resilience of the people. One such strategy for taking a more systematic approach to examining the inter-dependencies between people, climate and ecosystems is the Ecosystem Approach, which is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.

This three-year project (highlighted in the non-ACCCRN related policy briefs) now approaching the end, was supported by International Development Research Centre (IDRC).The project sought to scope and pilot activities that could improve the health of site-specific ecosystems and the latter's ability to provide goods and services in areas impacted by floods, droughts and other hydro-climatological hazards.These pilot activities were implemented in floodprone areas in the Rohini River Basin (in Uttar Pradesh, India), the Bagmati River Basin (in Nepal and Bihar, India), coastal Tamil Nadu and Saurashtra (Gujarat, India). While Winrock International India and ISET provided backstopping support, these activities were identified and implemented by other consortium partners: ISET-Nepal (in Nepal), Gorakhpur Environmental Action Group (GEAG, Uttar Pradesh India), Madras Institute of Development Studies (MIDS,Tamil Nadu India) and Utthan and Sara Ahmed (Gujarat India).

Eco-systems in Field sites

Field site	Ecosystems
Gujarat	Agroecosystem, coastal, marine, inland water
Tamil Nadu	Agroecosystem, coastal, marine and inland water
UP	Agroecosystem, inland water (flood plains), forest
Nepal	Agroecosystem, inland water (flood plains), forest

While it is acknowledged that small actions at the local level cannot make much difference until measures are taken to bring about change in the macro-ecological and systemic levels, the project attempted to demonstrate on ground adaptation activities that could be replicated at a larger level. Activities were selected after holding S*hared Learning Dialogues* (SLD)—a series and iterative process of consultations at various levels including the affected communities and other relevant government and non-government agencies.

The SLD process facilitated multiple objectives of sharing and learning between many actors, while at the same time building views on key issues and perceptions related to vulnerability and adaptation to climate change. SLDs also helped in dissemination and creating awareness among key actors at multiple levels, leading to deeper level engagement with them.

Specifically, the SLDs served the purpose of triggering various actors at various levels to come together as a *think-and-action tank,* increasing awareness about the degradation of ecosystems, its impact on the livelihoods of the communities and future scenarios that could develop in the context of climate change. What emerged from these SLDs were cross-learnings among various stakeholders and a set of options that could be tried to deal with the environmental and climatic stressors. Some of the interventions suggested by the communities, especially 'structural' or 'hard' infrastructure investments such as embankment construction that require huge investments could not be covered under the scope of this exercise. However, the SLDs helped identify and recommend policy gaps to the government agencies, who were also involved in this exercise. At the same time, the SLDs helped to highlight that 'structural' interventions might not be viable under an uncertain and highly variable climate.

Apart from the SLD, the preparatory work required field assessments of the principal ecosystem services at each study site. This exercise involved, apart from other facets of adaptation, the following that are of relevance to the theme of the paper:

1. An assessment (quantitative and qualitative) of the conditions of ecosystem service in pre, during and post-disaster situations in each area;
2. Trends in ecosystem services in the past and reasons for the trends;
3. Identification of drivers of changes in ecosystem services (for example, demographics, technology, land-use, pollution, etc.)
4. Understanding systems (technology, institutions, etc.) that help in resource-access;
5. Understanding patterns of access and consumption across various community groups;
6. Demand management systems (traditional, etc.); and,
7. Policies and programmes for management of ecosystem services

Implementation Pilots in Field Sites

The Rohini Basin, Eastern Uttar Pradesh by GEAG

Eastern Uttar Pradesh is one of the most flood affected regions of the Indo-Gangetic Plain. Located downstream of the Nepal Tarai, this region is crisscrossed by highly meandering rivers originating in the Chure Hills of Nepal. The terrain is generally flat, which aggravates waterlogging problems due to poor drainage.

Agriculture is the primary source of livelihood in the area. The majority of farmers' land holdings are small and marginal. Kharif (monsoon) and rabi (winter) crops constitute the major cropping seasons in the area, and are quite vulnerable to flooding and waterlogging. Paddy (Kharif) is the major crop of this area. Climate change is likely to exacerbate the vulnerability of the traditional cropping systems with possibly more frequent flooding due to low-intensity floods (Opitz-Stapleton 2008; Kull et al. 2008). Social and physical infrastructure services such as health, information and communication technology and irrigation and drainage, are generally poor in the area.

Ecosystem management options identified through an extensive round of SLDs as planned strategies to address current and future climate change projections were:

- Crop cycle management (Time and space management)
- Mixed and integrated farming in waterlogged area through land and water management
- Seed production
- Vegetable production
- Early maturing variety of paddy
- Nursery raising
- Multi-tier cropping

The above implementation pilots were found to be adaptive to the impacts of flooding and waterlogging either because they prevented crops from being destroyed by flooding or introduced resilient agricultural measures. However, other allied interventions in social (health etc.) and economic spheres (non-farm income generation avenues) also need to be taken up, as was demonstrated by the study, to build multiple layers of resiliency.

In Coastal Saurashtra, Gujarat by UTTHAN

Similar to other stretches of coastline, the Saurashtra coastline is rich in mangroves and vegetation. Mangroves provide fodder for cattle, diminish soil erosion at the seashore, reduce the impacts of storm surge and high tide and provide an appropriate environment for fish breeding.The hazards in this area are flash floods, cyclones and frequent droughts. Flash flooding, in combination with environmental degradation, has had a particularly devastating impact on mangrove stands.

Groundwater in the area has turned saline due to seawater intrusion into groundwater aquifers, which is exacerbated by groundwater mining.The salinisation of irrigation sources is forcing the majority of farmers to depend on monsoon-fed agriculture and shift to horticulture more-saline resistant varieties. Over years, the salinity has also impacted the crop yield.

Similar to other field sites, an extensive round of SLDs was conducted to scope out possible adaptation options that included:

- Large scale mangrove plantation and restoration
- Facilitating alternative income generation and livelihood activities (lobster fattening) by anticipating the fundamental changes in system due to sea level rise and increase groundwater degradation that are making agriculture unviable in the region
- Facilitating eco-sanitation models

In Coastal Tamilnadu by MIDS

In the coastal areas selected for implementing adaptation pilots, agriculture has been impacted adversely due to water scarcity, seawater intrusion, groundwater salinity and erratic rainfall.This has led to large-scale migration from coastal villages to other parts ofTamilnadu State and cities. In addition, mangroves have degraded due to reduced freshwater flow in the backwater rivers, industrial pollution and ecosystem mismanagement.

After series of SLDs, villagers tended to want structural measures to protect their ecosystems and livelihoods. Such initial interventions proposed included:

- Desilting of all village canals and ponds
- Construction of tailend regulators in canals and backwater rivers
- Construction of a sea wall

However, after assessing the feasibility and relative tradeoffs of the ecosystem management interventions vis-à-vis non-farm options, none of the above interventions were implemented. Communities came to understand the inability of such measures to protect against unknown future flood, sea level and storm surge impacts.Thus, through subsequent rounds of SLDs, the following non-structural interventions were probed:

- Non-farm activities such as construction, brick making, goat rearing, micro-credit facilities for small business, computer training to youth, emu farming, freshwater fish culture where freshwater ponds are large in number, English language coaching classes for village boys and girls and a good village information center
- Many village community people argued for better access to government offices
- More accurate weather information and cyclone warnings were, by and large, demanded by all participants.
- Better communication and information systems and community radio with more community participation and engagement.

Learnings and Ways Forward

From the above synopses of the various case study sites, it is evident that all the project areas have been impacted in one or more manifestations of hydro-climatological hazards (floods, droughts, cyclones, etc.) and increased climate variability. These natural hazards, in conjunction with pollution and ecosystem mismanagement, have lead to degradation of these already fragile ecosystems. Considering the limited capacity of ecosystems to sustain the provisioning of goods and services if they are being degraded, the adaptation options identified can be categorized as the following:

a) Promoting measures to revive ecosystem services through activities such as large-scale mangrove plantation
b) Altering the system to *fit* with the current level of ecosystem services, for example, shifting to early maturing varieties of paddy or promoting higher flood-resistant and/or salt tolerant crop varieties.
c) Promoting interventions that consider the opportunities emerging due to climate change by altering the fundamental systems on which livelihoods are based. For example, in coastal areas of Saurashtra, lobster fattening was considered to be more efficient and resilient than trying to work on reviving the severely degraded agro-ecosystem to its previous state.
d) It is striking to note that in all the project areas, non-farm interventions were also considered worth implementing as a means to bridge livelihood and income deficit at household levels.

The above mixed bag of options has yielded encouraging results with regard to building community resilience and adaptive capacity in the face of increased climate variability and uncertainty. These pilot interventions need to be taken forward through enabling sustainable, systemic environmental policies and also by ensuring their proper and effective implementation. Individuals and communities are already taking autonomous adaptive steps to perceived challenges with the information and resources they have at hand. Sometimes, however, these autonomous actions are maladaptive because they are based on limited understanding and access to information and/or resources. Significant capacity building efforts are needed, both on the part of policy makers and organisations that work with communities at the grassroots level, to support and encourage emerging adaptive behaviours that are beneficial and provide alternatives to maladaptive strategies.

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The Indian Policy Environment Related to Ecosystem Management

Winrock International India and ISET

Climate Change impacts and policy context

Local ecosystems are nested within a larger macro-level ecosystem and any disturbance in the smaller parts create imbalance in the whole ecosystem. A comprehensive, systemic, yet detailed view of ecosystems, ecosystem services, interlinkages between ecosystem functions and human and natural disturbance is needed to avoid destroying the fine balance that enables an ecosystem to be healthy. For many in India whose livelihoods are primarily dependent upon natural resources and ecosystem services, such as agriculture or aquaculture, the health of their local ecosystem is tantamount to economic survival. Policies of the government related to ecosystem management and enforcement of those policies can serve as critical actions stabilizing or destabilizing ecosystems.

There are various policies of the central Indian and state governments related to ecosystem management. While some of these policies are cross-sectoral, others are very sector specific (drinking water, coastal management, forestry, etc.). An assessment needs to be undertaken to see how some of these policies affect sustainable management of ecosystems and livelihoods in India.

Before we discuss some of the policies, it is appropriate to talk briefly about the nature of climate change impacts on natural systems as drafted in the First National Communication of the Government of India. The projected climate impacts cut across different sectors, communities and natural systems. They include:

- Reduction in the availability of freshwater and adverse impacts on agriculture and food security due to a possible decline in rainfall in some seasons of the year, greater rainfall variability and higher chance of extreme rainfall events in the monsoon season
- Boundary shifts for different forest types, with consequent implications for species diversity and forest-dependent communities
- Adverse impacts on natural ecosystems such as wetlands, mangroves, coral reefs and mountain ecosystems, affecting the food and livelihood security of populations dependent on those resources
- Threat of sea-level rise along coastal zones with implications for flooding, inundation of agricultural land and problems of water and sanitation

Climate change has received the highest attention possible in India. The Prime Minister of India recently set up a high-level advisory group on climate change issues in June of 2007, to coordinate national action plans for the assessment, adaptation, and mitigation of climate change. The advisory group is comprised of government and non-government representatives, including the Indian Ministers of External Affairs, Finance, Environment, Agriculture, Water Resources, and Science and Technology.

The Government of India launched the *National Action Plan on Climate Change* on 30 June 2008. The plan provides a directional shift toward a low-carbon development economy through multi-pronged, long-term and integrated strategies. Eight national missions form the core of the Action Plan: National Solar Mission; National Mission for Enhanced Energy Efficiency; National Mission on Sustainable Habitat; National Mission for a Green India; National Water Mission; National Mission for Sustaining the Himalayan Ecosystem; National Mission for Sustainable Agriculture; and the National Mission on Strategic Knowledge for Climate Change.

The relevant policies, some informed by the missions of the Action Plan, can be categorized into various categories: Development Policies, Climate Change and Adaptation Policies, Disaster Management Policies. We present a brief overview of each policy category with regard to ecosystem management and climate change.

The Policies related to Ecosystem Management

The National Water Policy

Water policies and programs in India are guided by the National Water Policy (2002) and the Integrated Water Resources Management strategy. Programmes that support adaptation include those promoting diverse and community-based irrigation systems and soil and water conservation; technological management of drought through early warning and flood mapping; appropriate drought and flood protection measures; maintenance of canals; and reduction of water requirements for crops and developing crops that are less dependent on water through application of biotechnologies. Other projects of the Ministry of Rural Development supporting adaptation to climate change of water resources include water harvesting through the construction of percolation tanks, contour bunds, and other structures. These types of projects fall under the Department of Soil and Water's conservation projects (Jal Sansadhan) and the Drought Prone Area Project (DPAP).

National Rural Employment Guarantee Scheme (NREGS)

The NREGS extended its operations to all the districts in India by 1st April 2008. The programme guarantees 100 days of wage employment to every household whose adult members volunteer to perform skilled manual work. NREGS also envisages the creation of durable assets and strengthening the livelihood, natural-resource base of the rural poor. These activities are intended to increase farm productivity along with the provisioning of wages to the rural poor. The NREG vests substantial powers with village level panchayats for effective implementation of the programme, and to increase community participation. In practice though, the panchayats have remained on the sidelines and communities are not being involved in the process. If the NREG is to succeed and sustain itself, it has to be managed at the village level *effectively* and *efficiently* with community buy-in and participation. Although on paper, village panchayats are supposed to manage NREGP, there is no evidence across the country that they are actually doing it. Gram sabhas are vital events in villages where discussions take place and approval of works to be taken up in the villages is sought. Villagers frequently know what is best for their village as they are living and interacting with their local ecosystem, although undue pressures or perceived opportunities can induce individuals to over-exploit resources. There is huge potential for transforming the NREG programme into an adaptation programme if proper guidelines for different agro-ecological contexts are made, more decision-making power and financial resources are devolved to communities, and incentives provided / guidelines enforced to protect ecosystems and ecosystem services.

Joint Forest Management

The Forest Policy of 1988 brought about a radical change in ecosystem management by shifting the focus from revenue generation to conservation, with a view to secure the subsistence needs of the local communities. The implementation of this policy was actuated by the Government of India's Resolution in 1990 (the JFM circular), which paved the way for the involvement of village communities and village assemblies in the regeneration of degraded forest lands. This policy obviously played a role in initiating a reversal of trends in deforestation during 1990-2000. The spread of the JFM institutions was rapid and by 1 January 2000, 1,02,48,586.41 ha of forest land was brought under the purview of JFM. The total number of JFM forest protection committees managing and protecting these forest lands now stands at 36,130.

However, JFM has failed in its attempt to utilize forest wealth to improve local livelihoods. The structure of the JFM is skewed towards the forest department and needs to be balanced with equal opportunities and rights to the participating communities. The annual rate of growth of forest cover has reduced since 2000, largely due to lack of policy enforcement and failure to provide adequate management power to communities.

Watershed Development Programme under DPAP, DDP and IWDP (Hariyali)

Watershed management was initiated in India to promote a rational utilization of land and water resources for optimum production, but with minimum hazard to natural and human resources. The watershed management policies reflected a recognition of the inter-relationships between land use, soil and water and the linkages between uplands and downstream areas.

Three key watershed development programmes of the Indian government – the Desert Development Programme, the Drought Prone Area Programme and the Integrated Watershed Development Programme - were consolidated into the Integrated Water Management (IWM) Programme for optimum use of resources, sustainable outcomes and integrated planning.

Each of these programmes is a micro-level effort focusing on rehabilitating "unproductive" land and the adoption of related activities for the benefit of the landless. The IWM programme adopts a multi-resource management approach involving all stakeholders within the watershed who, together as a group, cooperatively identify the resource issues and concerns of the watershed. The group then works to develop and implement a watershed plan with solutions that are environmentally, socially and economically sustainable.

Participatory watershed development projects have been seen as a solution to the problems of rural resource degradation and poverty alleviation in the past decade. Studies conducted on a large number of projects claim substantial improvements, mostly based on positive biophysical indicators of ecosystem health, as well as the new social institutions formed during the project. However, there is still little convincing evidence that such programmes have resulted in greater equity in the distribution of benefits and if they have been successful in alleviating poverty of the most vulnerable populations (Kerr 2000).

Disaster Management

The Disaster Management Act of 2005 envisages a paradigm shift from the erstwhile, relief-centric, post-disaster response to a proactive prevention, mitigation and preparedness-driven approach. It is hoped that a more proactive disaster management strategy will better conserve the developmental gains and minimize losses to lives, livelihoods and property in the event of a hazard. The entire process is supposed to keep the community at the centre-stage. The Act's momentum and sustenance is supposedly enabled through the collective efforts of all government agencies and NGOs.

Disaster risk is intimately connected to processes of human development and ecosystem management. Disasters put development at risk by wiping out infrastructure, assets and livelihood bases. At the same time, the development, ecosystem management and socio-economic choices made by individuals, communities and nations are actually responsible for turning a natural hazard event into a natural disaster event. The National Disaster Management Authority (NDMA), in consultation with the Planning Commission and other concerned Ministries of the Government of India, has worked out the modalities for scrutinizing the incorporation of disaster management concerns into the development plans of various ministries and departments. These guidelines have been circulated for compliance, while submitting proposals for approval by the Planning Commission.

Though the steps enacted by NDMA are a good beginning, a lot more needs to be done. The enforcement of the National Act 2005, enactment of the Disaster Management Act by various states, and the implementation of policies need to gather momentum. Knowledge and resource capacities of the communities, institutions and other stakeholders also need to be enhanced for effective disaster risk reduction (DRR). People need to have the information necessary to make informed decisions about why some behaviours increase disaster risk, and enforcement of regulations to reduce risky behaviour needs to occur. Furthermore, paper guidelines and plans without any budgetary allocation or clear lines of responsibility will not help mainstream proactive disaster management strategies.

A more integrated DRR approach calls for collaboration between the government agencies responsible for land use, development, agriculture and environmental planning and education, as well as other stakeholders responsible for disaster management.This approach requires decentralized DRR planning/ strategies with equity and an inclusive approach that can empower communities and open the window for local participation. Legislation can set standards and boundaries for action but, on its own, cannot induce people to follow these rules.There should be an inbuilt mechanism for monitoring and, enforcement needs to be strengthened with political commitment, transparency and responsibility. Reforms in the financial sector are needed for speeding up the processes of planning and implementing prevention and mitigation strategies, thus making development more resilient to disasters.

Coastal Regulation Policies

The Coastal Regulation Zone Notification (1991) is a specialised legislation aimed at protecting the coastal environment of India through the regulation of anthropogenic activities up to 500 metres from the high tide level.The Ministry of Environment and Forests (MOEF) has conditionally approved individual State Coastal Zone Management Plans. However, the States have yet to prepare a revised Coastal Zone Management Plan based amendment to the original legislation.The original coastal regulation zone (CRZ) rules that passed in February 1991 had seven sections. These rules have been amended nearly twice that many times in the past decade and the amendments have further weakened the coastal management rules for the sake of 'regional development'. Recent reports show that ports throughout India's shorelines are supposed to be managed as CRZ-I areas yet, government agencies do not seem to have a correct account of these ports.

Despite the fact that India's coastlines were traditionally a common property resource, the coastal communities have been expertly kept outside decision and policy-making circles at all levels. Most of the controversy with regard to the CZM Plans has raged around the CRZ-III areas that comprise most of the coastline (areas neither ecologically sensitive nor developed). It is development activities, such as related to tourism or industry, along such areas that have become powder-kegs in all debates on CRZ. With the CRZ Notification, coasts became part of a land classification regime that has never taken stakeholder participation seriously. Local communities or groups with limited socio-political say are frequently ignored in coastal land management decisions.The regulations have created centrally legislated and imposed user-rights on different groups along the coast. It has brought about constant conflict.

Taking into consideration the ecological and economic significance of mangroves, MOEF launched a Scheme on Conservation and Management of Mangroves and Coral Reefs in 1986.This scheme identified 38 mangrove areas for intensive conservation and management in the country with 100% central government assistance.The states of West Bengal, Orissa, Tamil Nadu, Karnataka, Goa, and Gujarat have been financially assisted by the Ministry to support intensive conservation and management of mangroves.

In addition to the government-funded programme, the M.S. Swaminathan Research Foundation (MSSRF) launched a programme to restore India's vanishing mangrove forests. MSSRG's programme was supported by the India-Canada Environment Facility with funding from the Canadian International Development Agency.The project helped restore 1,447 hectares of degraded mangrove forest on the east coast of India. A coastal bioshield movement has developed that promotes mangrove forests, plantation of casurina, palm, bamboo and other tree saplings to act as shields as well as carbon sinks. However, mangroves require specific environmental conditions (low shoreline, tidal flushing, variation in salinity levels, muddy substratum) therefore the need for non-mangrove bio-shields.

As per the State of Forest Report 1999, mangrove forest coverage in the country is 4,871 sq. km. Mangrove forest cover experienced a significant increase by 615 sq. km. during 1991-95. Coverage showed a more modest increase of 338 sq. km. during 1995-99. However, the pictures from earth observation satellites have revealed a gradual deterioration in mangrove ecosystems along both the eastern and western coastal belt of the country. Other estimates put the loss at 410 sq km between 1999-2003. Normally, mangroves are destroyed for fuel, fodder, timber and human habitation.These are also recklessly used for agriculture, aquaculture and industrial purposes without thought to long-term ecosystem and livelihood sustainability. Mangroves are now mostly confined to certain protected areas such as the Sunderbans, Bhitarkanika, Coringa, Nelapattu, Point Calimere and Pirotan (Marine) National Park.

The National Forest Commission recommends that mangroves should be officially classified as forests and should be placed under the control of State Forest Departments.The important mangrove areas need to be made Protected Areas if they are not so covered already and provisions need to be made to ensure that protected area status is enforced.The policy gaps in dealing with urban and peri-urban pollution flow into estuaries and its effects upon mangrove ecosystems/coral reefs also needs to be examined. However, what is needed most is to bring in the participation of the coastal communities in mangrove restoration programmes, decentralize management to local community bodies and ensure the communities have the incentives necessary to protect their local ecosystems.

Key Policy Issues

From the previous brief synopsis discussion, it is evident that there are diverse set of policy instruments in existence for dealing with different ecosystems and various aspects of ecosystems management in India.The actual effectiveness and enforceability of these policies is an entirely different matter, as with policies everywhere. However, in the context of climate change, variability and uncertainty, it becomes imperative to promote a process of adaptive learning involving actors from all levels, the villages on up to the national government, that feeds into policy implementation, making and enforcement. One such process, referred to as shared learning dialogues (SLDs) aids in creating the necessary awareness and capacity building at various levels and was used extensively in many of the projects covered by this set of policy briefs.This said, the policy terrain is not just to be seen as comprising only the government but, also market and civil society. Each group of actors has their own sets of desires and policies that combine to influence the behaviors and actions of key actors at various levels.