Environment

Water Community

Solution Exchange for the Water Community Discussion Summary

Research on Correlation between Water and Climate Change

Compiled by Nitya Jacob, Resource Person and Sunetra Lala, Research Associate

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From B. R. Neupane, United Nations Educational, Scientific and Cultural Organization (UNESCO), New Delhi

Posted 1 July 2009

I serve with the UNESCO's Cluster Office at New Delhi as the South Asia's Regional Programme Specialist for Water Sciences. We are organizing a 3-day workshop in August 2009 on Climate Change and Water Resources. The Delhi College of Engineering, Columbia University, CIP Trust in India and the Water Community are other promoters of this workshop. It will aim at assessing and adapting to the impacts of global hydrological change, both as a subset and principle indicator of global climate change. It will discuss what is needed for India and the region.

Fresh water resources are under stress around the world due to the exponential growth in population and per capita resource use, that are the drivers of energy consumption, anthropogenic climate, and hydrologic change. Significant research has been done on climate change assessment, mitigation and adaptation. However, there is only fragmentary research on global hydrologic change and data is limited, despite recognition of its importance.

This degradation of fresh water resources is a harbinger of a major crisis. Its impact on humans and the ecology may be at least as severe as that caused by greenhouse gasses. Increasing urbanization is altering areas near river courses and low lying coastal areas. Intensification of agriculture is contributing to deforestation and desertification. Increased water use for agriculture and urbanization is leading to hydrologic modifications. It is important to understand, predict and manage the potential impacts of climate change on regional and global water resources. Local human modifications of the hydrologic cycle through direct use, storage and redistribution, changes in land cover and use, and pollution, is a primary concern for local and global risk management. A changing climate increases the uncertainty associated with the future availability and variability of fresh water sources.

These are exacerbating factors of human-induced changes in the local, terrestrial hydrologic cycle. The effects are more pronounced at the river basin level. Since the immediate impacts of degradation of a freshwater resource are felt locally, assessment and recognition of the evolution of a *global water crisis* has been slow.

In view of the above, I request inputs from the members on the following:

1. What is the existing knowledge-base for climate change in the context of water resources in India?
2. What is the existing capacity in India to understand climate change, impact and adaptation issues?
3. In the context of (1) and (2) above, please suggest specific research areas and capacity building needs.
4. Climate change is a wider issue, thus regional cooperation and collective action are imperatives. Apropos, what should be the "regional responsibility" of India in South Asia (seso-stricto) to combat climate change and facilitate adaptation?

Your inputs will help us set the agenda for the workshop. **The members with the two best responses will be sponsored to attend the workshop and share their experiences.**

Responses were received, with thanks, from

1. **Ashok Jaitly, The Energy and Resources Institute (TERI), New Delhi (Response 1) (Response 2)**
2. **A. J. James, ICRA Management Consultancy Services Pvt. Ltd., Noida, Uttar Pradesh**
3. **Jyotiraj Patra, Oxford University Centre for the Environment, University of Oxford, United Kingdom**
4. **Prakash Kumar, United Nations Children's Fund (UNICEF), New Delhi**
5. **Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad (Response 1) (Response 2) (Response 3)**
6. **A. Narayanamoorthy, Centre for Rural Development, Alagappa University, Karaikudi, Tamil Nadu**
7. **D. K. Manavalan, Action For Food Production (AFPRO), New Delhi**
8. **Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan**
9. **Sakshi Saini, Institute of Home Economics, New Delhi**
10. **Pramel Gupta, Pragmatix Research and Advisory Services Pvt. Ltd, Bhopal**
11. **Harish Kumara B.K., Institute for Resource Analysis and Policy (IRAP), Hyderabad**
12. **K.A.S. Mani, Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS), Hyderabad**
13. **Saurabh Singh, Innervoice Foundation, Ballia, Uttar Pradesh**
14. **Abhishek Mendiratta, Independent Consultant, New Delhi**
15. **Meena Palaniappan, International Water and Communities Initiative, Pacific Institute, California, USA**
16. **Mihir Maitra, Individual Consultant, New Delhi**
17. **Joseph Plakkoottam, Development Management Network, Pune**
18. **Himanshu Thakkar, South Asia Network on Dams, Rivers and People (SANDRP), New Delhi (Response 1) (Response 2 *)**
19. **Paras R. Pujari, National Environmental Engineering Research Institute (NEERI), Nagpur**
20. **Devendra Sahai, Global Warming Reduction Centre, New Delhi**
21. **Prasoon Shukla, DBS Post Graduate College, Kanpur**
22. **Arun Jindal, Society for Sustainable Development, Karauli, Rajasthan**
23. **Neelima Garg, Uttarakhand Jal Sansthan, Uttarakhand**
24. **Ajit Seshadari, The Vigyan Vijay Foundation, New Delhi**
25. **Binukumar G. S., Institute for Resource Analysis and Policy, Hyderabad**

** Offline Contribution*

Further contributions are welcome!

Summary of Responses

There are several studies on impact of climate change on water in India. A few non-government organizations, universities and agencies including the World Bank and the UK Department for International Development (DFiD), have conducted limited studies on the topic in different parts of India.

However, these are localised studies; there is a lack of information at the national level and this hampers the capacity to understand the impacts and adaptation to climate change. Many of them consider only a few decades' data on rainfall and other parameters. Another problem is the lack of coordination between academia and policy implementers, as well as the divide between academic discipline and inter-disciplinary research.

Specific areas for climate change studies can understanding the well-established relationship between climate change and water that local people have identified. This traditional knowledge base needs scientific validation through further study. For this, NGOs working on these issues can form a strong network among themselves, the government, and universities.

This lack of information notwithstanding, India has a vast network of organizations working on climate, weather, and water resources. These include government departments, national level non-government organizations, and research institutes. It also has several think tanks on conflict resolution. In South Asia, there are many conflicts and disputes over trans-boundary water resources. It would be worthwhile to study the environmental peacemaking potential of water use. Given its preeminent position in South Asia, India can lead regional measures to combat climate change.

Existing knowledge base
Several organisations have studied the impact of climate change on water in India. The Energy and Resources Institute (TERI), New Delhi, has a long-running programme on climate change, including the impact on water resources and glaciers. The Asia Pacific Water Forum network designated it as the Knowledge Hub for Water and Climate Change Adaptation in South Asia.

The World Bank conducted a scoping study in Andhra Pradesh in 2005 and followed it up with a larger one covering Maharashtra, Andhra Pradesh and Orissa. These analyze the local impact of climate change on water, community coping strategies, and the government's response. DFiD has studied water management in semi-arid parts of India including the Water Resources Audit, community management of groundwater and the Water Households and Rural Livelihoods project.

The Indian Institute of Technology, Delhi, (IIT-Delhi) and the National Physical Laboratory have researched the links between water and climate change. IIT-Roorkee is working on a Glacier melt-Ganga Flow model. The Embassy of Norway has also supported research in this area. The Institute of Home Economics, University of Delhi, is studying the Gender Specific Impact of

Climate Change on Household Water Poverty, funded by the United Nations Framework Convention on Climate Change. Preliminary results indicate women will bear the impact of climate change as they are tasked with providing water and are the primary care givers; this will also reduce their ability to earn additional income. The challenge therefore is to raise their awareness about environmental resources that will prepare them to deal with climate change.

The Agro-Met cell of the Acharya N G Ranga Agriculture University, Hyderabad, studied climate variability from 1988-2007 in Telengana. These and other similar studies concluded climate change will have the largest effect on rainfall patterns. However, a paper published in the magazine Current Science that analyses 124 years' rainfall data, says the intensity of droughts has remained the same during the period.

The Pacific Institute and the Institute for Social and Environmental Transition are working with an Indian organization, TARU Leading Edge, on a project, Water Transitions: Helping the Formal and Informal Urban Water Sectors in Developing Country Cities Adapt to Climate Change. The US National Oceanic and Atmospheric Administration is funding the project. It will develop a set of tools to help water managers asses their water system's resilience to climatic and social variability, and another set for communities facing water problems.

The Intergovernmental Panel on Climate Change (IPCC) studied the effect of rising sea levels on Orissa and West Bengal; their study says a 1 m rise in sea levels will inundate 1700 sq km of prime agricultural land. Another similar work by a researcher from the Jawaharlal Nehru University, New Delhi, says this rise in the sea level will drown 5,763 sq km of coastal areas and put 7.1 million people at risk. In addition, the water quality in coastal aquifers will go down.

Several projects and studies indicate local action will be most effective to mitigate the impact of climate change on water. For example, the **Andhra Pradesh** Farmer Managed Groundwater System (APFAMGS) demonstrates how farmers jointly manage their groundwater resources. An earlier project, the Indo-Dutch APWELL project, also created 3,400 groundwater user groups of about 14,000 small and marginal farmers in seven drought prone districts of Andhra Pradesh. It helped them make optimal use of groundwater.

In **Rajasthan**, the Rajputana Society of Natural History documented the fall in groundwater levels through a survey of farmers. These farmers understood the changes in rainfall was due to climate change, and had changed their cropping patterns. They had stopped growing water intensive crops. In Karauli, the Society for Sustainable Development has supported the construction of 200 pokhers (village ponds) for irrigation and recharging groundwater.

In **Madhya Pradesh**, Pragmatix Research conducted a focus group discussion with farmers in a tribal village. These farmers have changed over from growing soya beans to coarse cereals and millets as they found soya cultivation had reduced soil moisture and local water resources and increase soil temperatures. This example showed the impact of cropping patterns on the local environment.

In **Gujarat**, the International Water Management Institute-Tata launched a programme called the North Gujarat Initiative. Over seven years, it has created the Society for Integrated Land and Water Management (SOFILWM). More than 1,000 farmers cultivating 20,000 hectares have adopted micro-irrigation and switched to crops that need less water than cereals.

In Uttarakhand, the Jal Sansthan has studied the effects of climate change on the seasonal discharge of 500 water sources (springs and *gadheras*). It found the water discharge from these sources has fallen by more than 50 percent in the past three years.

Specific research areas and capacity building

Some of the priority research areas are:

- River basin hydrogeological modelling and scenario building
- Meteorological studies
- Glaciology
- Watershed planning and management
- Water conservation
- Rainfed agriculture
- Traditional adaptation strategies
- Conflicts over sharing of natural resources in the context of climate change in South Asia
- Environmental peacemaking potential of water use
- Impact, outcome and adaptation strategies to climate change and globalisation
- Regional climate change prediction models based on long-term (60-70 years) data of rainfall, temperature, relative humidity, etc
- Impact of climate change on the socio-economic status of people in selected areas
- Incidents of climate change at the micro and national levels, their impact on water, vulnerability and coping mechanisms
- Community perceptions of the link between water problems and climate change
- Impact of climatic variability on hydrological regimes
- How to define water rights for groundwater management
- Impact of climate change on rainfall, evapotranspiration and surface run-off
- Temporal variation of run-off to the sea at a river basin level
- Capacity building of farmers to cope with rainfall variability
- Capacity building of communities to cope with water stress

Research on the impact of climate change in south Asia would thus strengthen cooperation between countries. It can form the basis of a South Asian regional initiative for climate change risk reduction. To conclude, India, with its well-established network of national, regional, and local organisaitons, can play a lead role in regional capacity building and research on the impact of climate change on water. This will help understand its regional obligations regarding water resources.

Comparative Experiences

Andhra Pradesh

Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS) Project uses Community-level Traditional Knowledge to adapt to Climate Change *(from K.A.S. Mani, Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS), Hyderabad)*

The APFAMGS project has prepared local communities to adapt to climate change by enhancing their capacities to make community-level decisions about livelihoods. Community members are encouraged to build on their existing knowledge and develop capacity to deal with climate change. As a result, 638 villages have now halted the decline in groundwater levels. Farmers through improved water use efficiency have also reduced groundwater pumping. Read more.

Groundwater User Groups help Share and Manage Water Efficiently *(from Joseph Plakkoottam, Development Management Network, Pune)*

To deal with water stress as a result of climate change, participatory hydrological monitoring was piloted by the APWELL Project in 1993. This provided marginal farmers access to groundwater in seven drought prone districts. Over 3,400 Groundwater User Groups were formed who shared water efficiently and cultivated dry crops. A recent impact assessment has shown that about 90% of the APWELL farmers still share water and make pro rata adjustments during droughts.

Gujarat

The North Gujarat Initiative enhances Farm Yield and Productivity *(from Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad; response 3)*
In order to deal with the impacts of climate change and augment groundwater IWMI-Tata initiated the North Gujarat Initiative. As part of this 7 year long project around 20,000 ha of irrigated land is now under micro-irrigation systems. Farmers have introduced fruit crops on 1000 ha of land which are not water intensive,replacing wheat and bajra. This has impacted the farm economy but studies on the groundwater regiem are yet to be taken up. Read more.

Madhya Pradesh

Farmers shift to Cultivating Coarse Cereals and Millets due to Erratic Rainfall Pattern *(from Pramel Gupta, Pragmatix Research and Advisory Services Pvt. Ltd, Bhopal)*
Farmers here grew coarse cereals and millets before they took to soya bean cultivation. In recent times the cost of growing soya bean has gone up due to pest attacks and erratic rainfall pattern. Farmers here have been forced to change their cropping pattern even though the minimum support price for soya bean is higher than that for coarse cereals. Due to the impacts of climate change on rainfall pattern they have now shifted back to coarse cereals and millets.

Rajasthan

Rajputana Society of Natural History (RSNH) Documents the impacts of Climate Change on Water Resources *(from Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan)*
RSNH's work has revealed that villagers now dig dugwells, borewells and tubewells at much greater depths than before to avail groundwater. People here no longer produce water intensive crops because of erratic monsoons. Villagers are of the opinion that this is due to the effects of climate change. RSNH is now working with the youth of the area to document the impacts of climate change and create awareness about how to mitigate its effects. Read more.

Society for Sustainable Development (SSD) helps Adapt to Climate Change by Constructing Ponds for Agricultural Needs *(from Arun Jindal, Society for Sustainable Development, Karauli, Rajasthan)*
SSD has adopted rainwater conservation in the Daangs area of Rajasthan to help combat the effects of climate change. Villagers here conserve water in ponds or *pokhers* and use it for irrigation. SSD has supported the revival and construction of more than 200 pokhers and all structures are used for irrigation and groundwater recharge. This has ensured water security for agriculture and is being used as an adaptive mechanism to combat climate change. Read more.

Related Resources

Recommended Documentation

Water Conflicts in India: A Million Revolts in the Making (*from Jyotiraj Patra, Oxford University Centre for the Environment, University of Oxford, United Kingdom)*
Book; by K. J. Joy, Suhas Paranjape, Biksham Gujja, Vinod Goud, Shruti Vispute; Forum for Policy Dialogue on Water Conflicts in India,; Routledge India; 2007;
Available at http://www.routledge.com/books/Water-Conflicts-in-India-isbn9780415424110

Brings together an impressive 63 case studies of water conflicts in India, a phenomenon which may rise as a result of climate change and water shortages

From Prakash Kumar, United Nations Children's Fund (UNICEF), New Delhi

Human Impact Report: Climate Change, The Anatomy of a Silent Crisis
Report; by Kofi Annan, Jan Egeland and Rajendra K. Pachauri; Global Humanitarian Forum; Geneva; 2009;
Available at http://www.ghfgeneva.org/Portals/0/pdfs/human_impact_report.pdf (PDF; Size: 3.32MB)

Details the silent crisis occurring around the world today as a result of global climate change, including its impacts on water resources

The Natural Fix? The Role of Ecosystems in Climate Mitigation
Report; by K. Trumper, M. Bertzky, B. Dickson, G. Jenkins and M. Manning,; United Nations Environment Porgramme; UNEP-WCMC, Cambridge; United Kindgom; 2009;
Available at http://www.grida.no/_res/site/file/publications/natural-fix/BioseqRRA_scr.pdf (PDF; Size: 8.34MB)

Stresses the need for conservation and management of ecosystems and water resources in order to be able to mitigate the impacts of climate change

Water Resources and Climate Change: An Indian Perspective (*from Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad; response 2)*
Article; by R.K. Mall; Central Ground Water Board; Current Science; Bangalore; June 2006;
Available at
http://docs.google.com/gview?a=v&q=cache:jt9jWCqGqpUJ:www.ias.ac.in/currsci/jun252006/1610.pdf+Water+Resources+and+Climate+Change:+An+Indian+Perspective&hl=en&gl=in

Describes how several studies show that climatic change is likely to significantly impact availability of freshwater resources in India

From Paras R. Pujari, National Environmental Engineering Research Institute (NEERI), Nagpur

Simulated Changes in Southeast Asian Monsoon Precipitation resulting from Anthropogenic Emissions
Article; by B. Bhaskaran and J. F. B. Mitchell; Hadley Centre for Climate Prediction and Research; International Journal of Climatology; USA; 1998; Permission Required: Yes, Paid publication
Available at
http://www3.interscience.wiley.com/journal/10003986/abstract?CRETRY=1&SRETRY=0

Examines the effect of climate change on simulated monsoon precipitation resulting from anthropogenic emissions over Southeast Asia

Climate Change and India: Vulnerability Assessment and Adaptation
Book; by P.R. Shukla; University Press; Hyderabad; 2004; Permission Required: Yes, Paid publication.
Available at http://www.universitiespress.com/display.asp?categoryID=1&isbn=978-81-7371-471-9

Provides assessments of the impacts, vulnerabilities and adaptation needs with regard to climate change and water resources in India

Sea Water Intrusion Studies near Kovaya Limestone Mine, Saurashtra Coast, India
Article; by R. Pujari and Abhay K. Soni; National Environmental Engineering Research Institute, Pune; Springer; The Netherlands; 2008; Permission Required: Yes, Paid publication
Available at http://www.springerlink.com/content/5w365533728128x2/

Describes how excessive withdrawal of groundwater near the Kovaya limestone mine has lead to salt water intrusion, which can deteriorate due to climate change

Earth's Sustainability depends on a Balance between P-R-E (*from Devendra Sahai, Global Warming Reduction Centre, New Delhi)*
Article; by Devendra Sahai; Global Warming Reduction Centre ; New Delhi; 2009
Available at http://www.solutionexchange-un.net.in/environment/cr/res01070901.doc (DOC; Size; 55KB)

Describes how sustainability of natural resources, including water, is dependent on sustainable growth of population, resources and the environment

Recommended Contacts and Experts

Prof. P.R. Pisharoty, Physical Research Laboratory (PRL), Gujarat *(from Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad; response 2*)
University Area, Ahmedabad 380009, Gujarat; Tel: 91-79-26301502; Fax: 91-79-26314900; info@prl.res.in; http://www.prl.res.in/

Expert who has studied the characteristics of Indian monsoon, highlighting the variability in rainfall and rainy days in different regions of India, due to climate change

Manoj Kumar Sharma, Society for Integrated Land and Water Management, Gujarat *(from Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad; response 3)*)
20, Karmcharinagar, Hanuman Tekri, Agola Road, Palanpur, District Banaskantha 385001, Gujarat; Tel: 91-2742-255609; manoj.sofilwm@gmail.com; http://sofilwm.org/background.html

Leads the North Gujarat Sustainable Groundwater Initiative, which attempts to adapt and mitigate the impacts of climate change on water resources

Recommended Organizations and Programmes

The Energy Resources Institute, New Delhi *(from Ashok Jaitly; response 1)*
Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi 110003; Tel: 91-11-24682100; Fax: 91-11-24682144; mailbox@teri.res.in; http://www.teriin.org/index.php?option=com_division&task=view_div&id=26; Contact Ashok Jaitly; Distinguished Fellow; Tel: 91-11-24682100; ajaitly@teri.res.in

Runs a research programme on climate change and its impacts on water, and has been designated as the Knowledge Hub for Water and Climate Change Adaption in South Asia

From A. J. James, ICRA Management Consultancy Services Pvt. Ltd., Noida, Uttar Pradesh

The World Bank, New Delhi
69-70, Lodi Estate, New Delhi 110003; Tel: 91-11-4617241; Fax: 91-11-4619393; info@worldbank.org; http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/INDIAEXTN/0,,menuPK:295589~pagePK:141159~piPK:141110~theSitePK:295584,00.html

Conducted a series of studies on climate change and its impact on water, including scoping studies in Andhra Pradesh, Maharashtra, Andhra Pradesh and Orissa

Department for International Development (DFID) India, New Delhi
B 28, Qutab Institutional Area, New Delhi, Delhi 110016; Tel: 91-11-26529123; Fax: 91-1126529296; enquiry@dfid.gov.uk; http://www.dfid.gov.uk/Where-we-work/Asia-South/India/

An international development aid agency, DFID has carried out a series of research studies on climate change and its impacts on water management in semi-arid India

Swedish International Development Cooperation Agency (SIDA), New Delhi

PO Box 392, Chandragupt Marg, Chanakyapuri New Delhi 110021; Tel: 91-11-26877819; Fax: 91-11-26873631; sida@sida.se;
http://www.sida.se/English/Countries-and-regions/Asia/India/Cooperation-in-figures/

Provides development co-operation across the world; SIDA has conducted research on adaptation to climate change in Rajasthan with regard to water resources

United Nations Environment Programme (UNEP), Kenya*(from Prakash Kumar, United Nations Children's Fund (UNICEF), New Delhi)*
United Nations Avenue, Gigiri, P.O. Box 30552, Nairobi, Kenya; Tel: 254-20-7621234; Fax: 254-20-7624489; unepinfo@unep.org; http://www.unep.org/climatechange/

UN agency provides leadership and partnership in caring for the environment, and has conducted research on the impacts of climate change on water resources

From D. K. Manavalan, Action For Food Production (AFPRO), New Delhi

Indian Institute of Technology-Delhi, New Delhi
Hauz Khas, New Delhi 110016; Tel: 91-11-26582037; Fax: 91-11-26582277;
webmaster@admin.iitd.ac.in; http://web.iitd.ac.in/~energycentre/

Inter-disciplinary centre deriving its strength from the disciplines of physics, chemistry, engineering, etc and has conducted research on water resources and climate change

Physical Research Laboratory, Gujarat
Navrangpura, Ahmedabad 380009, Gujarat; Tel: 91-79-26314000; Fax: 91-79-26314900;
info@prl.res.in; http://www.prl.res.in/

A research laboratory, which has conducted studies on the impacts on climate change on water resources in India

Norwegian Institute for Agriculture and Environment, Norway
Fr. A. Dahlsvei 20, Norway; Tel: 47-40-604100; Fax: 45-40-604100; Marina.Bleken@umb.no;
http://www.bioforsk.no/ikbViewer/page/prosjekt/tema?p_dimension_id=16927&p_menu_id=16934&p_sub_id=16928&p_dim2=16968

Runs the ClimaWater Project with IIT-Delhi, which aims to develop adaptation methods that will help address impacts of climate change on hydrological regimes

From Harish Kumara B.K., Institute for Resource Analysis and Policy (IRAP), Hyderabad

India Meteorological Department, New Delhi
Mausam Bhawan, Lodhi Road, New Delhi 110003; Tel: 91-11-4693186; lrf@imdpune.gov.in;
www.imd.ernet.in/main_new.htm

Researches data on stream flows, which can be used to assess the impacts of climate change on water resources, particularly flows in rivers and streams in India

Central Water Commission, New Delhi
Sewa Bhawan, R.K. Puram, New Delhi 110066; Tel: 91-11-26195516; Fax: 91-11-26195516;
smdte@mail.nic.in; http://cwc.gov.in/welcome.html

A premier technical organization of India in the field of water resources, and has information regarding stream flows in India which can be used to assess climate change

Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS) Project, Andhra Pradesh *(from K.A.S. Mani)*
H.No. 12-13-373, 1st Floor, Street No. 18, Chakravarthula Nilayam, Sadashiva Nagar Colony, Tarnaka, Secunderabad 500017, Andhra Pradesh; Tel: 91-40-27014730; Fax: 91-40-27014937;

plapfamgs@sify.com; http://www.apfamgs.org; Contact K.A.S. Mani; Project Leader; Tel: 91-40-27014730; ananthmaniin@yahoo.com

Working to prepare local communities to adapt to climate variability and water shortages by enhancing their capacities to make community level decisions

From Meena Palaniappan, International Water and Communities Initiative, Pacific Institute, California, USA

Institute for Social and Environmental Transition, USA
948 North Street, Suite 9, Boulder, Colorado 80304, U.S.A; Tel: 1-720-5640650; Fax: 1-720-5640653; moenchm@i-s-e-t.org; http://www.i-s-e-t.org/

Conducts research and implements programme on climate change, disaster risk reduction and water resources in South Asia

Pacific Institute, USA
654 13th Street, Preservation Park, Oakland, California 94612, U.S.A.; Tel: 1-510-2511600; Fax: 1-510-2512203; info@pacinst.org; http://www.pacinst.org/topics/water_and_sustainability/climate_change/; Contact Meena Palaniappan; Director of International Water and Communities Initiative; Tel: 1-510-417-5998; mpal@pacinst.org

Conducts interdisciplinary research and partners with various stakeholders on issues relating to impacts of climate change on water resources

From Mihir Maitra, Individual Consultant, New Delhi

Centre for Water and Power Research Station, Maharashtra
Khadakwasla, Pune 411024, Maharashtra; Tel: 91-20-24380552; Fax: 91-20-24381004; wapis@cwprs.gov.in; http://cwprs.gov.in/main_eng.HTM

A part of the Union Ministry of Water Resources, it is one of the foremost organizations in the world in the field of hydraulics and allied research, including water resources, etc

Central Ground Water Board, New Delhi
CGWB, Faridabad, Haryana; Tel: 91-129-2419106; Fax: 91-129-2412524 cgwb@nic.in; http://cgwb.gov.in/GroundWater/Hydrogeological_Surveys.htm

Carries out hydrogeological studies to provide information on groundwater occurrence in different terrains which is essential for future planning of groundwater development

Indian Council of Agricultural Research, New Delhi
Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi 110114; Tel: 91-11-25823415; Fax: 91-11-25842660; mpandey@icar.org.in; http://www.icar.org.in/welcome.html

Conducts research on on-farm water management to enhance water-use efficiency, which can be used to mitigate impacts of climate change

Centre for Water Resource Development and Management, Kerala
Kunnamangalam, Kozhikode 673571, Kerala; Tel: 91-495-2357151; Fax: 91-495-2351808; ed@cwrdm.org; http://www.cwrdm.org/Research.htm

Conducts research on agricultural water requirement, which can be used to adapt to climate change and water shortages

Indian Institute of Technology Roorkee, Uttarakhand
Roorkee 247667, Uttarakhand; Tel: 91-1332-285311; regis@iitr.ernet.in; http://www.iitr.ac.in/departments/HY/pages/index.html

Is working on a Glacier melt-Ganga flow model, which can be used to predict the impacts of climate change on water resources

From Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad; response 3

Society for Promoting Participative Ecosystem Management (SOPPECOM), Maharashtra
16, Kale Park, Someshwarwadi Road, Pashan, Pune 411008, Maharashtra; Tel: 91-20-25880786; Fax: 91-20-25886542; soppecom@gmail.com; http://www.soppecom.org/focus.htm

Watershed development has been one of the important areas of SOPPECOM's involvement, and research in this area can be used to adapt to climate change

Ashoka Trust for Research in Ecology and the Environment (ATREE), Karnataka
Royal Enclave, Srirampura, Jakkur Post, Bangalore 560064, Karnataka; Tel: 91-80-23635555; Fax: 91-80-2363555; info@atree.org; http://www.atree.org/con_programs.html

Works on conservation programmes, including conservation of water resources and watershed development programmes

Gujarat Institute of Development Research (GIRD), Gujarat
Gota, Ahmedabad 380060, Gujarat; Tel: 91-2717-242366; Fax: 91-2717-242365; gidr@gidr.ac.in; http://www.gidr.ac.in/institute.php

Studies on natural resources, including water resources and climate change constitute one of the important and rapidly expanding portfolios of research at GIDR

Society for Integrated Land and Water Management, Gujarat
20, Karmcharinagar, Hanuman Tekri, Agola Road, Palanpur, District Banaskantha 385001, Gujarat; Tel: 91-2742-255609; info@sofilwm.org; http://sofilwm.org/resource_agencies.html20, Karmcharinagar, Hanuman Tekri, Agola Road, Palanpur 385001, District Banaskantha, Gujarat

Initiated the North Gujarat Initiative project, which aims to manage groundwater resources in the area to deal with water stress as a result of climate change

Sir Ratan Tata Trust, Maharashtra
Bombay House, Homi Mody Street, Mumbai 400001, Maharashtra; Tel: 91-22-66658282; Fax: 91-22-66658013; srtt@tata.com; http://www.srtt.org/institutional_grants/rural_livelihoods_communities/water_sector_research.htm

Supports an initiative in north Gujarat which aims to help farmers adapt to water shortages as a result of climate change

Rajputana Society of Natural History (RSNH), Rajasthan *(from Satya Prakash Mehra)*
Shanti Kutir, Keoladeo National Park, Bharatpur 321001, Rajasthan; 91-5644-225950; greenmunia@yahoo.co.in; Contact Satya Prakash Mehra; Tel: 91-9829144163; greenmunia@yahoo.co.in

Works with the youth in Rajasthan to bring awareness about climate change and its impacts on water resources

Society for Sustainable Development, Rajasthan *(from Arun Jindal)*
Jagdamba Colony, Karauli 322241, Rajasthan; Tel: 91-7464-250288; jindal1965@gmail.com

Has adopted rainwater conservation and management in the Daangs area of Rajasthan to help combat the effects of climate change on water resources

Related Consolidated Replies

Climate Change Adaptation in Water, Agriculture and Coastal Areas, from Preeti Soni, Energy and Environment Division, UNDP, New Delhi (Experiences). Water Community and Food and Nutrition Security Community, Solution Exchange India,
Issued 31 December 2007. Available at http://www.solutionexchange-un.net.in/environment/cr/cr-se-wes-food-27110701.pdf (PDF, Size: 56 KB)

Discusses the larger context of climate change, shares environmental impact findings and mentions experiences with climate resilient water, agriculture and coastal management practices

Gendered Adaptations to Water Shortages and Climate Change, from Meenakshi Kathel, United Nations Development Programme (UNDP), New Delhi (Experience). Gender Community and Water Community, Solution Exchange India,
Issued 26 March 2008. Available at http://www.solutionexchange-un.net.in/gender/cr/cr-se-gen-we s-global-15120701.pdf (PDF, Size: 202 KB)

Shares experiences and examples for developing gender sensitive adaptation strategies for combating the effects of climate change, diminishing livelihoods and water shortages

Inputs for Water Mission of National Action Plan on Climate Change, from Himanshu Thakkar, South Asia Network on Dams, Rivers and People (SANDRP), New Delhi (Advice, Examples). Water Community, Solution Exchange India,
Issued 30 January 2009. Available at http://www.solutionexchange-un.net.in/environment/cr/cr-se-wes-29120801.pdf (PDF, Size: 140KB)

Inputs on specific initiatives to be included in the NWM, considering the past water-related missions and the varying agro-ecological situations across India

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Responses in Full

Ashok Jaitly, The Energy and Resources Institute (TERI), New Delhi *(response 1)*

This is an extremely important and timely discussion from both perspectives - on the one hand, India (indeed South Asia as a whole), is facing a very serious water crisis and, at the same time, the impact of climate change is being increasingly felt. However, despite a great deal of rhetoric and generalized opinion there is very little informed debate. This is because the existing knowledge base is very weak and not much serious research is being undertaken on the correlation between climate change and water resources. In fact, whatever little scientific information is available relates primarily to the global perspective as contained in the IPCC reports. What is urgently required is to develop regional, national and river basin level knowledge bases. This is not an easy task and would require considerable human and financial resources.

Clearly, in the absence of a strong knowledge base our capacity to understand climate change impact and adaptation issues would be severely constrained. In fact, the institutional capacity to address these issues is very limited. Research institutes studying the various related subjects are few and far between. In fact, they can be counted on one's fingertips! In view of the water crisis this gap is not just ironic but tragic!

In the light of such an alarming situation the scope for research and capacity building is immense. Some of the priority technical aspects that come to mind are river basin hydrogeological modelling and scenario building, meteorological studies and glaciology, which would build information bases about climate change impacts. Simultaneously, watershed planning and management, water conservation and rainfed agriculture could be some priority subjects from the adaptation perspective. It is also important to study and document traditional adaptation strategies, particularly in disaster prone areas like coastal zones and flood prone

areas. Indeed, the research and capacity building needs are subjects eminently suited for a serious debate in order to formulate a comprehensive and multi-disciplinary agenda.

There can be no two opinions that climate change requires a collective response at the regional level. I have argued for this strongly in a paper that I wrote last year on the subject. Unfortunately, SAARC which could be the appropriate forum for concerted action in South Asia has not been effective at all despite high sounding declarations. Collaborative research and exchange between South Asian institutes and NGOs could show the way for more effective cooperation.

Members would be aware that TERI has a strong programme on climate change related research and policy advocacy. This includes water resources and glaciers. Very recently, the Asia Pacific Water Forum network has designated TERI as the Knowledge Hub for Water and Climate Change Adaption in South Asia and we would be taking up this challenging task very shortly. We would welcome participation by members interested in related areas of research.

A. J. James, ICRA Management Consultancy Services Pvt. Ltd., Noida, Uttar Pradesh

This addresses the first question of the query. The World Bank has done a series of studies on climate change and its impact on water. The first was a small scoping study in Andhra Pradesh in 2005, followed by a larger study in Maharashtra, Andhra Pradesh and Orissa analyzing the possible local impact (technical modeling exercise), community coping strategies (on-the-ground survey) and existing government responses (to floods and droughts). Both reports are available with the World Bank New Delhi office and possibly on-line.

The third is the Andhra Pradesh Drought Adaptation Initiative (APDAI) which has piloted around 18 village-level community-based interventions across a range of stakeholders and natural resources (e.g., soil fertility for small farmers, collective use of groundwater for protective irrigation, lease farming on barren land, backyard poultry, animal vaccination, etc). The connection with water is through the collective borewell irrigation pilot. The first round of results is in and the final will be available by December 2009.

Prior to these, DFID carried out a series of research studies on water management in semi-arid India. Projects and outputs include the Water Resources Audit (for KAWAD and APRLP), the community management of groundwater (COMMAN Project), Water Households and Rural Livelihoods (WHIRL) Project, AGRAR, etc., all of which are available with the local DFID office in New Delhi.

There is also some work on climate change linked adaptation in Rajasthan by SIDA, which the New Delhi SIDA office should be able to help with.

Jyotiraj Patra, Oxford University Centre for the Environment, University of Oxford, United Kingdom

Such a timely initiative must look into the complexities and uncertainties associated with global climate change and water resources at various levels. The lack of sufficient knowledge and information on these issues has already been highlighted.

Much of it has to do with the way knowledge is being produced through scientific research and investigations, and subsequently disseminated. Going beyond the traditional divide of academic disciplines and interdisciplinary approaches, the process of knowledge production has to be cooperative and adaptive. Such a process and practice of knowledge production is crucial to

understand the various dimensions and changes of a life supporting, albeit critical natural resource, like water. Measures and strategies based on this co-produced knowledge to reduce the risks and vulnerabilities of water resources and that of the entire social-ecological systems build around these resources will then be socially robust and politically just. The existing capacity and content of knowledge producers and the knowledge base would develop to a great extent through this.

Secondly, the challenges and barriers associated with water resources development and societal growth in a changing world could be overcome and bridged through systematic integration of this knowledge into processes of policy formulation and implementation. Thus, the need of the hour is to institutionalize a systematic, sustainable, and equitable process of engagement among knowledge producers, policy makers, resource managers, water users, community groups, and the media in India. These could be instituted by establishing various boundary organizations (Cash et al., 2003, Knowledge Systems for Sustainable development, PNAS 100-14, 8086-8091) in India. Such a boundary organization will provide an enabling platform for diverse stakeholders to engage in a collaborative learning process thus ensuring the robustness of the knowledge base to timely and effectively address unforeseen challenges and surprises.

Discussions on water resources and climate change would be incomplete without deliberating on issues and dimension of 'conflicts.' In South Asia, conflicts and disputes over transboundary water resources are many and vary both in intensity and scale. Instances of conflicts arising out of sharing and use of a critical natural resource like water are many (Ref: Water conflicts in India: a million revolts in the making, Routledge). Many of these studies dissect out the underlying causes including the contributing socio-economic and political factors associated with such conflicts.

Research to understand and tap the 'environmental peacemaking' potentials associated with water use would be worth undertaking. Research outputs could very well contribute as double-edged swords, by strengthening cooperative actions towards trust building and simultaneously building confidence and capacity towards a regional level initiative for climate change risk reduction and human security in South Asia.

A second strand of research could study the impacts, outcomes and adaptation strategies in situations of double exposure (Leichenko and O' Brien 2008) arising because of multi-scalar interplay among forces of global environmental change and globalization. This is well manifested in and around coastal districts of Orissa, where climate change induced changes as well as technological and financial investments for port development are on the rise.

Prakash Kumar, United Nations Children's Fund (UNICEF), New Delhi

I attach two reports on climate change and its ever-growing burden on humanity, which may be of relevance to the discussion:

Climate Change Responsible for 300,000 Deaths A Year

A new report from Global Humanitarian Forum calculates that more than 300 million people are seriously affected by climate change at a total economic cost of $125 billion per year. For more please read
http://www.albaeco.se/en/index.php?option=com_content&task=view&id=65&Itemid=8

Planet's Ecosystems Our Best Allies in the Struggle against Climate Change

We must invest more in the conservation, rehabilitation and management of ecosystems in order to maximize the potential for removing carbon from the atmosphere, says a new report from UNEP. For more please read

http://www.albaeco.se/en/index.php?option=com_content&task=view&id=57&Itemid=8

Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad *(response 1)*

I am extremely happy to see the detailed response by Ashok Jaitly on climate change and water resources.

I would like to add a few more points, which seem to have been missed out in the discussions:

1. There is a lot of "scare-mongering" about the impact of climate change on water resources in India. I haven't seen any study which systematically assesses the climate change phenomenon (at the regional level), and then analyzes its impact on water resources. In response to an old query in Solution exchange, I have mentioned the problem of attribution vis-à-vis climate change and its impact on hydrology. As I pointed out, often, stream-flow reduction, is attributed to climate change even without any concrete evidences to the climate change phenomenon (data on long term change in rainfall; rainy days; intensity of rainfall; temperature, relative humidity, etc). Change in land use or changes in groundwater draft in upper catchments of basins can cause significant reductions in stream-flows, even without reduction in rainfall. This is part of the rhetoric.

2. Often, climate change modeling studies claim to be climate change impact studies. However, they seem to be nothing but hydrological models, which integrate climate variables in them to simulate their effects on runoff, runoff intensity, river discharge etc. Needless to say, our ability to use them for any purpose depends on how far the assumptions made about climate change used in the model are reliable! Therefore, what is needed is a robust "climate change prediction model (CCPM)", which is fully calibrated with historical (observed) data of rainfall, atmospheric temperature, relatively humidity etc. for reasonably long time duration (say 60-70 years). It can then be used in basic hydrological models to predict stream flows, soil moisture, evaporation, etc. Today, we seem to know very little about what global and regional parameters are used in these CCPMs, which predict climate change, and the logic behind choosing those parameters.

3. One possible alternative would be to use long-term data on climate variables (that are expected to cause effects on hydrological variables) and then use the hydrological observations for selected basins, and then do multi- variant analysis, with model provisions to capture the effect of land use change, and groundwater draft.

4. There is a general tendency to interpret climate variability with climate change. In many regions in India, climate variability is a known phenomenon. If we look at the mean daily temperature or humidity or rainfall of a particular day of a particular month in a region from 60-70 year data, this would be evident. Due to such variations, changes in stream-flows, soil moisture, etc can be observed in river basins. Kutch receives a mean annual rainfall of 350mm, but the actual annual rainfall is found to vary from 50mm to 800mm. A severe drought is expected in the earlier case and floods in the latter one.

5. Therefore, the need of the hour (as pointed out by Ashok Jaitly) is to develop robust climate change prediction models for different regions, and then use them in river basin hydrological models. This is not an easy task. Forecasting climate variables (such as rainfall, temperature) based on short term observations would be catastrophic. The danger would be bigger if we start using some very "local" data for making macro

predictions. Most of the doomsday prophecies about climate change and its impacts here in India seem to be based on such short duration data about localized phenomenon.

I would request the community members to correct me if I am wrong in my understanding of the situation. Hope this is somewhat useful for the ongoing debate.

A. Narayanamoorthy, Centre for Rural Development, Alagappa University, Karaikudi, Tamil Nadu

I completely agree with Dinesh Kumar's comments on climate change and water resources in India. We do not have any systematic studies indicating the impact of climate change on different river basins. We ought to study the changes more carefully by adding climatic as well as non-climatic factors, including institutional factors to understand whether climate change is really impacting our water resources. For example, areas under tank irrigation in India have been coming down over the last 40 years despite insignificant reduction in the total quantum of rainfall. Can we attribute this reduction to climatic factors? Several changes have taken place in the institutions that manage water resources in India, which are impacting the availability of water resources. Therefore, while studying the impacts of climate change on water resources, we need to include the institutional factors and players, who need to establish policies for tackling the possible impacts of climate change on water resources in India.

D. K. Manavalan, Action For Food Production (AFPRO), New Delhi

We very much agree with Ashok Jaitly's concern on the subject and suggestions to develop regional national and global level knowledge bases. However, as far as understanding of impact of climate change and adaptation issues are concerned, people living in remote areas have found well-established relationships between water and climate change in many parts of India. This traditional knowledge base needs to be studied in depth for scientific validation. Climate change in recent years has certainly posed serious threats on the sustainability of eco-system in general, and water resources in particular. Many organizations (government and NGOs) are working on the issue of water and climate change but have not been able to create a scientific data base and visible impact. Experiences of research institutions like IIT-Delhi, Physical Research Laboratory - Ahmedabad and more recently Norwegian Embassy (CLIMAWATER Project) are worth mentioning. Yet, there needs to be a comprehensive knowledge base in the sector as opined by World Bank, which can be achieved only by collaborative efforts. Of course, improving common efforts and contributions between government organizations (research units and universities) are necessary, but it is more important to build up a strong link between NGOs working on the field and research units. Very often good ideas stay on paper without any "translation" on the ground. Good ideas, models, and best practices are not replicated rather adapted outside of the project boundary (geographical and temporal). To improve this situation, we need to strengthen the extension services and I think that each implementing NGO should have a partner or partners from the research field and vice-versa.

Most of the regions all along the western and central part India receive moderate to high sun shine both in intensity and duration. It has a direct bearing on climate and geo-thermal regime. Also, close relationship between climate, forest cover, soil, and water are well established; disturbance in any of the mentioned elements adversely affect the others. For example, irresponsible land management plays a critical role in water flows and quality; yet the question of how to ensure that the community/farmers internalize the negative impact they have on water has been barely explored. The ambitious plans for integrated catchments management have frequently fallen short of their targets, often due to lack of appropriate tools/approaches for encouraging improved land management. It is seen that many of the research findings, which

are situation and site specific are some times put into practice uniformly throughout the country ignoring the spatial variation, thereby reducing the effectiveness of the technology.

Further, we are pleased to learn that Asia Water Forum network has designated TERI as the Knowledge Hub for Water and Climate Change Adaptation in South Asia. Being a network member of National Communication (NATCOM-2) and having a rich practical experience on the subject, AFPRO would like to participate in the programme on climate change related research and policy advocacy. However, we would appreciate if you could clarify the kind of participation you are looking for from the members of Water Community

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Satya Prakash Mehra, Rajputana Society of Natural History (RSNH), Rajasthan

Here are some inputs based on our preliminary work in Rajasthan (southern and north-eastern parts):

We have seen that no prior work on the issue of water resources and climate change has been conducted here. We used a questionnaire survey to assess the decreasing level of groundwater table as well as past sources of surface water. The target group was mainly agriculturists. This group provided us with information on the previous level of the water table and present status. They used to dig wells/borewells/tubewells and present depth at which water is available was there main data for our analysis. This was further crossed checked through the related governmental departments of water, irrigation, and agriculture. The weather reports were used to assess the monsoons and the fluctuations along with other climatic data.

The issue of climate change is still new for a large population of Indians. As per our experiences it is below 5% of the total in our working sites. When asked in rural areas, many people agreed and than started sharing their experiences on the changing climate pattern of the area. They have no ideas about how to cope with the impacts. According to them, the erratic monsoon is the result of climate change. This has changed their agriculture pattern. Water intensive crops are no longer produced. They were willing to join hands with the scientific community to find solutions. Further, the youth is actively working on such issues. The youth members of RSNH are creating mass awareness along with IYCN in Rajasthan. The activities which play a role in combating climate change are discussed and possible alternatives are considered.

Selection of sites which have visible impacts of climate change can be chosen as research sites. This will help to study the impacts of climate change on the socio-economic aspects of people of the selected sites. This will also provide information on whether climate change has altered the eco-system of the site - positive and negative alterations. Additionally, this will provide information on vanishing species (whether related to climate change), expansion of exotic species, etc.

India is among the 12 mega-biodiversity countries of the world. The diversity of habitats and respective fauna is of major concern prior to making any climate change models. The recommendations should focus on regional micro-planning through involvement of regional agencies which may be individuals, NGOs, government departments, institutes, etc. India could play a major role in presenting the issues on the global platform. Before presenting any model or recommendation, the regional workshops could be organized keeping in mind the habitats/bio-geographic regions, etc. Rural population should be given priority as their experiences are from the grassroots level especially when it is concerned with the water related issues. Therefore, their practical experience should be given priority along with other scientific inputs.

Sakshi Saini, Institute of Home Economics, New Delhi

I am currently working with the Institute of Home Economics, Delhi University on “Gender Specific Impact of Climate Change on Household Water Poverty” a project funded by UNFCCC. I would like to share few of the findings during the course of our project work.

Climate change is a reality. It is likely to affect all aspects of human life directly or indirectly. Due to rapid industrialization and urbanization the concentration of green house gases is increasing at a very fast pace. During the last 100 years global surface temperature has increased by 0.74 °C and in the next 100 years it is likely to increase by 1.1 to 6.4 °C. It is the poor who are impacted the most because of limited adaptive capacity. The problem is all the more acute in case of poor women who lack access to formal education or training, and have very limited financial resources. Their vulnerability to climate change increases because of prevailing social inequalities and ascribed social and economic roles. This manifests itself in differences in property rights, access to information, lack of employment, and unequal access to resources. With climatic changes quality and quantity of water will deteriorate, as women are the key persons responsible for its accession and management will suffer the most. Due to increase in number and intensity of diseases their care giving burden will increase manifold which will further impact their income generation capacity. Thus, the challenge is to provide them with enhanced awareness, knowledge about their environmental resources, and impact of climate change on their lives and increase their preparedness to deal with climate change.

Metropolitan cities due to rapid urbanization and industrialization are facing acute shortage of resources. Thus, it becomes all the more important to increase the adaptive capacity of urban poor women. Adaptive capacity being a function of income, wealth, education, and awareness needs to be increased by creating awareness and giving knowledge to people so that they can take steps not only to adapt but also to mitigate climate change. Some of the adaptation strategies can be better method of water purification, rainwater harvesting, repairs of handpumps and taps by women themselves, application of intermediate technology for bringing home water, redistribution of gender division of roles, etc. These adaption strategies can only be implemented if the community is willing to participate in the activity, thus highlighting the need to impart them with knowledge and awareness.

Pramel Gupta, Pragmatix Research and Advisory Services Pvt. Ltd, Bhopal

I want to share my recent experience on how farmers are adapting to climate change. This is based on a focus group discussion with farmers in a tribal village in Madhya Pradesh about changing over from growing soya bean to coarse cereals and millets. The farmers told me the cost of growing soya bean has gone up over the years due to pest attacks and erratic rain fall. As a result, they have been forced to change their cropping pattern. This is despite the fact that the minimum support price for soya bean is higher than that for coarse cereals and millets and it is more profitable.

The farmers also said before they started soya bean cultivation, they used to grow coarse cereals and millets. At the time, soil moisture and associated vegetation was abundant. This vegetation helped to reduce soil erosion during rainfall by breaking the force of the rain. There was little inter-cultivation, that protected the top soil. In addition, village wells and ponds had adequate water, and the groundwater level was high.

When they started cultivating soya bean, because of better returns and urged by market forces, they also started inter-cultivation. Soya bean does not require stagnant water, so the farmers had to ensure their fields were drained of excess water during the rainy season. This accelerated soil erosion; the soil washed off and silted up the village ponds.

Due to continued cultivation of soya bean over 8-10 years, heavy soil erosion has taken place. As the farmers could not retain the water during the *kharif* season, they had a water shortage during the rabi season. The storage capacity of local water bodies was reduced due to the siltation. Owing to lower soil moisture, temperatures during the *rabi* season were higher, there was increased need for irrigation and more groundwater withdrawal through tube wells. In addition, there was a loss of biodiversity and increased contamination of water sources from pesticides used on soya bean.

This prompted the farmers to give up soya bean cultivation and revert to their earlier course cereals and millets for food security. This has reduced soil erosion, siltation in ponds and increased the water availability during the rabi season.

This little understanding of farmers on negative impact of soya bean crop on environment is highly appreciable. I am not against of any crop but there is need to strike a balance. On the one side we are promoting crops like soya bean because of global forces and good processing facilities. But on the other side, we are creating huge environmental losses leading to the climate change in the region without understanding the crop's nature and characteristics.

I think these issues need further research so that people realize the negative impact of the crop and regional government can make better policies for environment protection as well farmers benefits.

Harish Kumara B.K., Institute for Resource Analysis and Policy (IRAP), Hyderabad

In India, I do not know of any studies, based on empirical evidence, on climate change. To take up any climate change studies I feel we need to consider few things:

- Are there any incidents of climate change at the micro or even regional level
- If so, to what extent has the climate has changed and what are the parameters
- What is the impact on water resources
- What is the vulnerability level (this can be determined from the level of the impact)
- Finally, what are the coping or adaptation mechanisms at the community level

I have seen in Karnataka's villages that climate change is one of the driving forces for water resources and water shortage. Communities have adapted to climate change just like they have to other natural disasters. Most climate change studies so far, including those by IPCC and NATCOM, have not taken a holistic approach. We need to consider others parameters like, changes in water utilization, demand, land use land changes and stream flow. We (Indian researchers) can study climate change but we need adequate data on climate, including rainfall, temperature, humidity, for more than 100 years. This is available with the Meteorological Department and the Central water Commission has information about stream flows. However, they do not make it available for public use. In my observations in Hassan district, Karnataka, most of the water resources problems have been caused due to increase in water utilization, changes in cropping pattern, encroachments of tanks, and lakes.

K.A.S. Mani, Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS), Hyderabad

India as a country is dependent on the weather gods for agriculture, power generation, agro-based industries and as a result the people and economy are critically dependent on it. It is the general observation that high climate variability in the form of delayed onset of monsoon, large variability in monsoon rainfall and long breaks between rainy days are being experienced over the years across the country. The study of climate variability from 1988-2007 by Acharya NG

Ranga Agriculture University Agro-Met cell Hyderabad, using data from number of met stations in Telengana shows visible shifts in monsoon patterns, increasing temperature, evapo-transpiration and deficit soil moisture availability affecting the crop yields. Numerous other studies have concluded that climate change impact in many parts of India is likely to be the highest on rainfall occurrence and distribution.

My experience of working with communities show that climate variability is perceptible in rural India and leaves a noticeable impact on people. Poor and marginal farmers solely dependent on rainfed agriculture are already making informed decisions in the form of coping strategies by extending the soil moisture availability through reduced tilling, addition of organic matter to soils, mulching, delaying the sowing dates, going for short duration hardy seed varieties, managing pests and diseases using local knowledge and most importantly diversifying their livelihoods. Local level adaptations for coping with climate variability are as a means of reducing investment costs for minimizing the risks. Continued inaction to climate variability tends to aggravate land degradation, thereby severely affecting the environment. This is largely being addressed at the local level in a silent way. The resilience in the communities to face consequences of climate change/variability goes unrecognized. The need is to link the ground-level action with the research taking place in big institutes.

The Andhra Pradesh Farmers Managed Groundwater Systems (APFAMGS) project is working for preparing local communities for adapting to climate variability by enhancing their capacities to make community level decisions about their livelihood systems. Key strategy of the proposed project is the knowledge based approach where community members are encouraged to build on their existing knowledge and develop reflective capacity to look through the aspects of climate variability. The strategy is to use knowledge (both local and in the public domain) as the main input (as compared to technology/investment) to get a proper perspective for managing climate variability. APFAMGS experience shows that when knowledge levels are enhanced, enlightened communities are united to make difficult choices willingly, for minimizing risks.

APFAMGS experience of working in 638 villages spread over 7 districts of Andhra Pradesh, has over 4 years (2004-08) altered the water balance positively by halting the decline in groundwater levels. Several thousand farmers through improved water use efficiency have reduced groundwater pumping while at the same time generated increased wealth. The project has demonstrated that knowledge generated though a reflective and collective sharing process tends to get internalized within the community, which would assist them take proactive actions to ward off the dysfunctional consequences.

In the area of climate change the project strategy is to promote community initiative for improving the performance and enhancing the use of natural resources, control of wastages and improve the overall sustainability of the natural resource base. This approach generates improved value for the existing investment while avoiding wasteful expenditure on new investments and thereby checking indebtedness at the farmers' end. The project will provide an opportunity for community to collect all technical (meteorology, crop, seed, fertilizers, pests, diseases, and livelihood) data on their own. The community shall access information on formal science and technology along with local traditions and knowledge through a process of group learning using Climate Change School (CCS). CCS approach enables community to diagnose different issues related to the problem and identify local solution as well as access proven results. Non Formal Education Tools are adopted to facilitate better understanding of science in their discussions while they also participate in short and long term experiments in the fields to test various solutions emerging from the regular interactions. The graduates emerging from the schools shall emerge as a critical human resource base and an asset in training the larger community.

Stakeholder consultation, participation in research on the subject of climate variability/change is critical for identifying relevant activities to be implemented for coping with it. The need is to identify the appropriate institutional arrangements that can help in the development of knowledge base adaptation at the community level to guide in the implementation of long-term climate change adaptation initiatives.

Saurabh Singh, Innervoice Foundation, Ballia, Uttar Pradesh

We work with arsenic affected people in Ballia (Uttar Pradesh) and Bhojpur (Bihar). During our field trips we had several meetings with villagers who have never gone to any university or college who could make a link between their water woes and climate change. This is their traditional knowledge and understanding of climate and nature. I must confess I could not disagree with them. However I do feel that this is a topic that really needs to be deliberated upon.

We really appreciate this theme and hope that the issues pertaining to water that plagues different part of our country, including that of arsenic contamination of water, fluoride contamination, etc will be dealt with in details during the conference in relation to climate change. This would really help to learn about climate change and its impact on habitations.

Abhishek Mendiratta, Independent Consultant, New Delhi

The first category of disasters arises from endemic disasters such as hurricanes, typhoons, and cyclical flooding (monsoon). The essential characteristic in this category is that learning from past experiences can inform future strategies so a degree of anticipation of the nature and scope of an event can be factored into the process. The second category arises from unanticipated disasters that are rapid, catastrophic, but are not part of a cyclical pattern in a given area and thus not part of any institutional or social memory. An example of this could be a Tsunami arising from a tectonic event manifesting in an area that is not usually Tsunami-prone.

Greenhouse gas mitigation measures are important in the mid and long-term to reduce the impact of climate change. However, water-related disasters which seem to be triggered by climate change, such as floods, wind storms, droughts, and high-tides, have already increased their frequencies and magnitudes. Such situations require us to move beyond “reaction” to “prevention” in addressing the water-related disasters. The “High-level Expert Panel on Water and Disasters/UNSGAB” was created to contribute to the acceleration of this paradigm shift. ”Prevention” in the context of disaster management means the application of adaptation measures to prepare for changing risks, which is expected to contribute to the reduction of loss of lives and human properties. Statistical data used to evaluate return periods of water-related hazards and expected economic damages for cost-benefit analysis is insufficient for the planning of infrastructures and their operations. This is due to current hydrologic uncertainties caused by climate change. Water Infrastructures and management rely on innovative structural and non-structural design concepts in order to be more resilient against future extreme events. It is important to mainstream new design criteria for the planning of various water infrastructures in IWRM for the management of water-related disasters in this changing world.

Globally water is not limiting for agriculture. But heterogeneity prevails and some countries will increasingly face water scarcity. Future needs of water for food are huge and up-to-date water management systems will be required at a large scale. External factors, like: impacts of bio-fuel products, climate changes, virtual water trade, changes in agri-market and the price of commodities have a strong influence on the engine of the agriculture activities. Such changes will require additional adaptations in the development of water management measures to ensure

global food production and to reduce the probability of a severe crisis in the coming years. Modernization of irrigation and drainage systems in the broad sense (technical, management, financial, environmental) will be required at a large-scale, especially in emerging countries, to achieve the required increase in food production, also in some cases to save water.

A 3-day workshop in August 2009 on Climate Change and Water Resources should address the above mentioned concerns. Climate change is a wider issue, thus India should take its own responsibility before taking the regional responsibility.

Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad *(response 2)*

Responding to K.A.S. Mani's point about climatic variability: this is extremely important for countries like India to know about "climatic variability" before we start thinking about the "climate change" impacts. Many regions in India experience high variability in climate, and communities have adapted to it, as he correctly points out. But, where I disagree with Mani is when he seems to suggest that this is a new phenomenon (please correct me if I am wrong in reading it).

Prof. P. R. Pisharoty's work in PRL on characteristics of Indian monsoon highlights the variability in rainfall and rainy days in different regions of India. Naturally, we can find similar variability in humidity, etc. with rainfall changes. But, it is wrong to perceive this as climate change.

The study of climatic variability (change in rainfall, timing of onset of monsoon, number of rainy days and intensity of rains etc. from year to year) and its impact on hydrological regimes (HR) will be extremely valuable in predicting the nature of impacts of climate change on HR in certain regions. But, how the communities adapt to climate variability will not tell much about whether they could deal with climate change phenomenon, as the long term impacts of both would be very different.

While a region experiences floods and droughts due to climatic variability, the impact of climate change in the same region may be either increase in frequency of floods (with lower frequency of droughts), or increase in frequency of droughts (with lower frequency of floods), depending on air is warming up and where the region is located (humid or arid). Hence, the way communities will have to adapt to this will be totally different from the way they adapt to floods and droughts in normal case. The adaptive capacities will have to be different.

A paper in Current Science, by R. K. Mall et al. (2006) which looked at data for 124 years, does not show any increase in intensity of droughts in India (in terms of area affected). Short duration meteorological data for 20 years (mooted by Dr. Mani) will be at best useful to examine whether there is variability in climatic parameters, but cannot tell us whether it is changing in a particular direction. Therefore, I am sure, what Dr. Mani is referring to is inter-annual variability in climatic parameters.

The east African example would be very useful here to illustrate the impacts of climate change and climatic variability. There has been continuous decline in rainfall in east Africa for more than 35 years from mid 60s. Research has shown significant impact of this on East Africa's GDP growth. The scholars call it "Africa's growth tragedy". This may not be part of "climate change" phenomenon, but the impact could be more or less same, if CC occurs in a region which does not have adaptive capabilities.

Whereas what we continue to experience (and experiencing for centuries) is the variability in rainfall and its other characteristics from year to year (in most places), with higher rainfall in

some years, and lower than normal rainfall in some other years. In a year, with normal or above normal rains, there could be bumper production of kharif and winter crops (with slightly higher GDP growth), while in a drought year which proceeds, the production might come down with some effect on GDP growth.

While rainfall/climatic variability pose new challenges for water planners, it is not a tragedy per se. In such situations, we may have to build storages and increase “multi-annual storages” in the basins which experience it. Whereas if the rainfall consistently declines or increases, building those storages may not help.

Meena Palaniappan, International Water and Communities Initiative, Pacific Institute, California, USA

We are pleased that the issue of climate and water is getting attention on the national and regional level. Pacific Institute and the Institute for Social and Environmental Transition (ISET), two NGOs who have worked on the science and policy of climate, water resources, management, and adaptation for the past two decades, and TARU leading edge, our India partner, are working on a U.S. National Oceanic and Atmospheric Administration funded project entitled "Water Transitions: Helping the Formal and Informal Urban Water Sectors in Developing Country Cities Adapt to Climate Change." Our project location is Indore, India.

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 and informal sectors 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, we are bringing together water stakeholders including water managers, NGOs, and the private sector to identify key needs that water stakeholders have in responding to climate change.

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 both 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.

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 needed tools. 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.

In the next phase, we will be developing a self-reliance tool for communities facing water insecurity as a result of climate change.

We look forward to finding out more details about the August workshop that you are hosting, and look forward to presenting our work in this venue. We are committed to presenting at the Scientific and Technical Conference on Adapting to Climate Change in Asia, that will be held August 29-30 in Nepal.

Mihir Maitra, Individual Consultant, New Delhi

Leaving aside the celestial changes like increase in solar activity, change in earth's orbit, change in earth's tilt angle etc. on which obviously we have no control, our concern on climate change is primarily associated with the changes in the composition of the lower atmosphere. An increase in the greenhouse gases in the atmosphere is believed to increase the absorption and/or entrapment of reflected solar radiation leading to global warming and thus climate change.

To begin with, we must therefore continue to restrict emission of the greenhouse gases particularly the Carbon dioxide along with undertaking extensive research on how to sequester these gases. Shifting to cleaner technologies (in the context of emission) and large scale plantation of trees seem to be the right direction towards remedy. However, it is getting increasingly evident that with our present life style and varying global interests, it is no longer possible to reduce emission and hence accept global warming as an inevitable reality.

Since this is a global phenomenon, it would require concerted global level efforts in closely monitoring the changes so as to combat the adverse effects. However, only a few global agencies can actually undertake or have the mandate to undertake such studies involving the monitoring of global variables such as temperature, ocean currents, air currents, status of ozone layer, incidence of harmful rays etc. in their seasonal and spatial dimensions. Presently, I presume, the predictions are being made based on model studies and simple extrapolation using data from research and monitoring. At the National level, India should be a part of these global studies by contributing both in terms of funds and specialist manpower, so that we can have an access to the latest findings and act accordingly in dealing with International priorities. India should begin by establishing a "think tank" committee for this purpose.

It is also evident that the most pronounced and visible effect of global warming would be on the Hydologic Cycle. Consequently, the inter-related factors like precipitation, evaporation, evapo-transpiration, run off and infiltration are likely to change perceptibly in a cause-effect-cause cycle leading to climate change. Increased frequency of flood and drought and shifts in their spatial occurrences are predicted. This demands the creation of a responsive basin level institution capable of addressing the challenges of the managing the water resources and the associated ecology. Another remedial measure is to create large scale water storage facilities including the use of the immense storage facility available in the sub-surface formations created due to depleted groundwater through artificial groundwater recharge structures under controlled conditions.

A number of Indian agencies like Indian Meteorological Department (IMD), Central water Commission (CWC), Centre for Water and Power Research Station, Central Ground Water Board (CGWB), Indian Council of Agricultural Research (ICAR), Centre for Water Resource Development and Management (CWRDM) etc. are involved in research and investigation related to water resources in the country. A great deal can be achieved simply by reorienting and re-focusing the functioning of these agencies towards the research and monitoring of the effects of climate change on water resources. Many of these agencies are already in the possession of the necessary expertise and historical data base. Selected researchers could be imparted with the necessary training and encouraged to produce some country specific predictive models. IIT, Roorkee is known to be working on a "Glacier melt-Ganga flow model". Other Universities can

contribute a lot in preparing predictive models for example, if average global temperature increases by 30^0 C by 2050 then what happens to the country.

Since agriculture would be the front runner in taking the impact of climate change, large scale initiatives are required to enable our farmers to cope with the challenges. To a farmer it does not matter whether, the prevailing climatic situation is due to the climate change or the usual climate variability, they have to simply learn to cope with the changing climatic conditions. To this end, our entire "extension services" are to be geared towards vulnerability assessment and capacity building of our farmers. K.A.S. Mani has already shared with the Solution Exchange Water Community the APFAGMS approach that has enabled farmers to control the use of their tube wells (ground water) in meeting their own crop water requirements. Expansion of similar approach in other parts of the country is desirable.

In the context of climate change the Indian sub-continent is physiographically a well defined entity for model studies with Himalayas in the North and coast line all around the rest. India should not be clubbed with its Asian neighbours but rather be seen as a South Asian Block. Large Indian rivers are inter-state in nature. India therefore has to take its smaller neighbours on board in discharging its regional responsibilities.

Ashok Jaitly, The Energy and Resources Institute (TERI), New Delhi *(response 2)*

My compliments to K.A.S Mani for having introduced such a critical element into what should be the appropriate agenda for research on Water and Climate Change.

I would fully support his recommendations. We, in TERI, would certainly adopt this approach in our research work by integrating theoretical/conceptual study with ground level knowledge and action. Without the latter, no amount of institutional research work can be meaningful, particularly on a subject in which there is already such a great deal of accumulated knowledge amongst communities.

The 'Climate Change School' approach of APFAMGS is extremely interesting and could be an effective tool towards demystifying climate change science and spreading awareness as well as disseminating new ideas.

Joseph Plakkoottam, Development Management Network, Pune

As someone involved in project formulation and implementation in the water management sector for a while, I would like to share a few facts that would be useful for the participants of this discussion on water use and climate change.

Participatory hydrological monitoring was piloted in the Indo-Dutch APWELL Project (1995-2003), the main objective of which was to provide access to groups of small and marginal farmers to groundwater in seven drought prone districts of Andhra Pradesh. The main achievement of the APWELL Project was forming over 3400 Groundwater User Groups of comprising about 14,000 small and marginal farmers families, who have been sharing water efficiently and been cultivating irrigated dry crops earning good returns. The project focused on capacity building of farmers to take judicious decisions on making the best productive use of scarce groundwater. Recent impact assessments have shown that about 90% of the APWELL farmers still share water and do make pro rata adjustments in times of groundwater stress (e.g., due to drought).

Having successfully demonstrated that small and marginal farmers can gain access to groundwater and use it wisely, APWELL Project was proposed to be upscaled with greater focus

on demand side management of groundwater involving the entire user community in a hydrological unit /delineated watershed (APWELL II).

Bilateral funding for APWELL II did not materialize and only the "demystifying science" part of the APWELL II proposal was hived out and developed as a far smaller project as APFAMGS Project (2003-2008).

The lessons and experience of the APWELL Project have been mainstreamed in recent water management projects. The Andhra Pradesh Community Based Tank Management Project (2007-12), which plans to restore 3,000 minor irrigation tanks in 21 districts, has incorporated a major subcomponent on Participatory Groundwater Management (PGM) focusing on demand side management. Lessons from the considerable experience of the APWELL Project in farmer mobilization, mainstreaming women in decision making in agriculture, involvement of NGOs in community facilitation, promotion of sustainable agricultural practices and wise water use have been incorporated in the project design (2005-06). Early lessons from the APFAMGS Project have also been taken into account.

The methodologies and techniques piloted by APWELL and enhanced for "demystifying groundwater science" by APFAMGS, are definitely valuable contributions. The knowledge levels and communication skills of groundwater users in the APFAMGS villages are admirable. However, I would like to list a few points regarding the outcome of APFAMGS which need more careful analysis and open discussion:

The APFAGMS implementation period (2004-08) coincides with "good monsoons" in Andhra Pradesh. A majority of the hydrological units where APFAMGS Project was implemented fall in "safe" or "semi-critical" groundwater development zones. Therefore, APFAMGS experience is rather limited as far as "critical" and "over-exploited" groundwater assessment units are concerned.

Groundwater users would naturally draw less water from their borewells during kharif when the rainfall is good. Restriction of power supply to 7 hours also reduces groundwater draft.

K.A.S. Mani's note says: "APFAMGS experience of working in 638 villages spread over 7 districts of Andhra Pradesh, has over 4 years (2004-08) altered the water balance positively by halting the decline in groundwater levels." What then is the impact of good monsoons on water levels?

Again, the note says: "Several thousand farmers through improved water use efficiency have reduced groundwater pumping while at the same time generated increased wealth."

The APFAMGS Project strategy "is to use knowledge (both local and in the public domain) as the main input (as compared to technology/investment)". Water use efficiency was achieved through sustainable practices, mainly through micro-irrigation (drip and sprinklers, obtained by groundwater users from other projects). Agreed that the farmers used the knowledge gained from the project for sourcing these inputs, but investments in the area of water use efficiency would have strengthened it further. I would strongly argue that critical inputs such as micro-irrigation equipment must be included in Project cost.

Most of the documentation on the APWELL Project is available with me and I would be happy to share these with those who would like to know more.

Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad *(response 3)*

I believe the concerns raised by Joseph Plakkoottam are much broader than what they appear to be; and therefore deserve great merit and attention. There seem to be problems of attribution (causes and effects) in analyzing the impact of many water-related development projects. A recent large scale survey attempting to understand the impact of watershed programme also raised concerns about the sanctity of attributing improved groundwater situation and increased well irrigation in villages to watershed interventions in the village (as part of a collaborative research study by SOPPECOM, ATREE and GIDR).

A lot of the changes in groundwater level (especially in hard rock areas) occur after a very good monsoon, whether we do watershed interventions or not. As Joseph Plakkoottam points out, recharge increases significantly, and abstraction reduces. So, there is double impact, both positive. In a drought year also, there is double impact, but both negative. Recharge significantly reduces, but abstraction goes up even during kharif season.

Hence, the methodology adopted for evaluating the impact of the interventions needs to be carefully designed. Perhaps, comparing the treated watershed with one (with similar rainfall pattern, land use, and geo-hydrology) without interventions on a time scale would help rather than simply looking at the well hydrographs of the treated watershed longitudinally.

What is most important in terms of success of groundwater management project is how many of the farmers have adopted water saving irrigation devices and practices, and how much area is covered; how many farmers have shifted to water-efficient crops.

Then at the next level, we can ask whether this actually saves water at the field level and also at the aggregate farm level. Here, the question of what farmers do with the saved water is also important (drips and sprinklers may not save water everywhere, though it might increase the yield); also farmers can expand the irrigated area with saved water).

At the third level, we should know whether all these hydrological changes observed are happening because of the interventions. In many aquifers, what happens to the water level is not the result of the "level of groundwater draft" alone, but also the result of changes in regional groundwater flow patterns, outflows/inflows, in addition to natural recharge. In some cases, increased pumping does not lead to change in rate of decline in water level, whereas in some other cases, increased recharge does not lead to change in rate of water table build-up. So, without any interventions also, there could be improvements in groundwater balance in an area.

Educating the farmers about climate variability and climate change is extremely valuable. But, with lack of well-defined water rights in groundwater, there is no incentive for farmers to cut down water use. Reduced or increased groundwater pumping would at best be an outcome of what farmers do (through technologies and practices) to sustain their income at times of water stress. But, no farmer is going to change the water use behaviour just because there is scarcity of water at the societal level due to climate change or climate variability. The solution lies in equipping the farmers with new crops, technologies and practices (through on farm demos, action research and extension work) that will help them generate same or more income with less use of groundwater, without compromising on the returns per unit of land.

The challenge is to align the private interests of the farmers with societal interests.

The initiative in north Gujarat for managing for groundwater would provide some insights on what individual farmers can do to reduce the impact of groundwater stress, and what could be the impact. As a result of 7 years of interventions initiated by IWMI-Tata water policy program under a project called "North Gujarat Initiative", (later on hived off from IWMI and now a new organization called Society for Integrated Land and Water Management-SOFILWM), there are

significant outcomes seen. Around 50,000 acres (20,000 ha) of irrigated land is under MI systems (drips and micro sprinklers) covering several row crops. Around 1000 ha of land is under newly introduced fruit crops (pomegranate and lemon) which are low water intensive, and which replaced wheat and summer bajra. More than 1,000 farmers are now using organic manure prepared through vermi-composting. Studies are available on the physical impacts of the interventions at the field level and impacts on farm economy. But, studies on groundwater regime are yet to be taken up. As I was involved in this project as its manager for 6 years, I would like to keep away from discussions.

Sir Ratan Tata Trust continues to support this initiative. Manoj Kumar Sharma (manoj.sofilwm@gmail.com), who is heading SOFILWM, would be in a better position to inform you about the latest status of the programme and its achievements.

Experience of APWELL with community action (by farmer groups) at the village level would provide a lot of insights into whether it is possible to get the communities around managing water.

I know there is a lot of deviation from the main topic here. I am really sorry for that and hope the community would bear with me for that. But, if we want to know the impact of climate change, adaptive strategies, and their effectiveness, we may have to do a little lateral thinking.

Himanshu Thakkar, South Asia Network on Dams, Rivers and People (SANDRP), New Delhi *(response 1)*

This letter below is trying to make a very important statement on the issue of climate change, India's National Action Plan on Climate Change in general and comprehensive statement on India's National Water Mission, as part of NAPCC.

To,
The Prime Minister of India
7, Race Course Road,
New Delhi 110 001

Respected Sir,

Sub: Urgent Concerns on NAPCC and the National Water Mission

We understand that you and the Advisory Council on Climate Change appointed by you are in the process of finalizing the India's National Action Plan on Climate Change (NAPCC) and the various missions under the same. We are writing this letter on our concerns regarding the National Water Mission under the NAPCC, including some general concerns about the NAPCC.

NAPCC: Issues of Process There was no participatory or transparent process in formulation of NAPCC or even the specific mission plans. When this issue was raised before the joint secretary, Union Ministry of Environment and Forests in September 2008, he said that participatory process should be taken up during formulation of the mission plans, but that too has not happened. This cannot be an acceptable situation in any democracy.

Hiding behind the Poor The Indian government rightly says that they have no obligation to reduce GHG emissions, following the 'common but differentiated responsibility' as described in the United Nations Framework Convention on Climate Change. The question is why should the same principles of common but differentiated responsibility and equity not be followed within India?

Limited solutions All the solutions offered across the world so far suffer from the limitation in that they do not advocate reduction in consumption by the rich, including the rich in India. They all seem to suggest the current consumption levels and even further growth in the same is possible to be sustained by various measures, including improving efficiency, shifting to renewable sources of energy and electricity and by adopting some new technologies. While Indian government claims it is serious about mitigation, in practice the entire development trajectory and specific policy measures such as promoting cheap flights and finance for cheap and luxury cars promotes the growth of emissions, and largely directed to benefited the rich. Can the earth's environment sustain this if all the people of the earth were to aspire for the level of consumption now being used by the US and Western Europe?

No Targets for emission reduction The NAPCC has no targets for emission reduction for India, except saying that India will not exceed the levels of emissions of the developed countries. India would be suffering greater impacts of climate change than US, Europe or even China. Within India, the worst sufferers would be the most vulnerable sections depending on the natural resources for their daily needs, including the adivasis, the coastal communities, the mountain communities, the rainfed farmers, and the land less and the marginal and small farmers, the dalits, the women, and the poor. The contribution of these vulnerable sections of our population is very little or negative. It is in the name of development of these people that Indian government is saying we need to be allowed to increase emissions. The trouble, Sir, is that these people are not participant selecting the development options. Nor are these people benefiting from most of the mega projects of development. On the contrary, they are suffering further deprivations of their meager resources. If the development of these sections, including providing access to electricity to them is the objective, then there are options available that does not require India to continue to increase emissions. In fact, for the sake of these vulnerable sections, the government of India needs to commit nationally (NOT internationally) that India will cap its emissions; the target can be decided through a participatory process.

CDM Projects: In principle the claimed benefits from CDM projects and carbon trade projects are suspect. Therefore, our government should dissociate itself from it as soon as possible. But as long as it continues as part of the Kyoto Protocol, some minimum steps need to be taken to bring it under public scrutiny. Firstly, most projects that have entered the CDM (Clean Development Mechanism) projects pipeline from India can not be described as part of sustainable development, nor do they deserve CDM credits. It is noteworthy that most of these are controlled by corporate bodies that are responsible for lion's share of India's corporate emissions. While the practice of giving single window clearance to such projects must stop, we need to make the host country clearance process transparent, accountable, participatory and credible. Moreover, at least 75% of the credits from the credibly certified projects should go to local community development projects.

THE WATER SECTOR Some important recommendations in this sector include the following.

- **Opportunity to reverse wrong policies** The climate change has provided us a unique, once in a century kind of opportunity to assess, review, reflect on our current policies and reverse them where we have gone wrong. This opportunity must not be allowed to go waste. We have a water crisis on our hands even without the climate change, with vast populations still not able to get water for basic human existence. More areas are slipping into problem zones as we are not able to ensure source sustainability, because of the wrong kind of priorities we have been following in water sector. Unfortunately, the National Water Mission and the NAPCC largely is a collection of business as usual projects, dominated by the misguided and wrong agenda of more big dams, more big surface storages, more large hydro projects, interlinking of rivers and so on.

- **Participatory process for NWM** As noted above the NWM proposed as of now has been formulated through a completely non participatory and non transparent process. A time bound, participatory process for formulation of National Water Mission, National Mission for Sustainable Agriculture and other missions should be taken up immediately. Credible panels can be set up for taking up this exercise.
- **Knowledge Base** Our knowledge base on the issue of impacts of climate change on water sector is poor. Immediately, we need to come out with a report on the state of the knowledge in this sector and we need to have annual updates of this report.
- **National Water Security Act** We urgently need an act from 3 perspectives: Human Right perspective, including health perspective, ensuring provision of clean water required for drinking and domestic water use for all as a right; from the livelihood perspective, ensuring the water required for livelihood for all and from the ecologic perspective, ensuring protection of rivers, wetlands, lakes, water bodies, etc.
- **Review and Reform Water Law** There is an urgent need to review prevailing water related laws in India from the perspective of environmental sustainability and social justice. Current laws are totally devoid of an ecological, integrated approach and do not reflect the basic principle that water is a common good and a precious natural resource. The reform process needs to be undertaken in a highly participatory, decentralized, and democratic way.
- **Common Property Resource** Water is essentially common property resource, the state, where it has a role, is supposed to act as a trustee of this resource, in the interest of the people's basic needs, in a democratic manner, which is not the situation today. The proposition in NAPCC and NWM proposal for developing "new regulatory structures, combined with appropriate entitlements and pricing" and also the urban water regime seem more like a push towards privatization of water resources, which is not helpful, appropriate, or acceptable.
- **Governance** The fundamental problem plaguing this sector is lack of democratic governance. We urgently need to set up legal and institutional mechanisms to ensure bottom up, participatory, accountable governance for rivers, for pollution control, river action plans, for groundwater, for environment management, irrigation systems, lakes, rivers, wetlands, embankments, canals, pipelines, and other related water infrastructure. Such project/river specific committees should be statutory bodies with powers to make necessary mandatory orders with respect to the functioning of the projects.
- **Reservoir Operation Committees** To ensure proper and optimum functioning of the existing and under construction reservoirs in the interest of the people, each reservoir should have a reservoir operation committee, in which at least 50% members should come from the local communities. As a first step in this direction, the reservoir operation rules and actual reservoir operation details (inflows, outflows, levels, capacities, and anticipated inflows) should all be made public *suo moto* on daily basis for each large dam in India.
- **Irrigation Efficiency** The objective of increasing the irrigation efficacy is much needed and laudable, but such attempts in the past has not succeeded because of the top down, unaccountable governance systems. Such attempts have left the governance of the larger systems outside the reach of the water users. Unless this is changed fundamentally, such attempts won't succeed.
- **Groundwater** We need to understand that groundwater is India's national water lifeline and will remain so for many years to come for all sorts of water use. If we want to ensure sustainable existence of this lifeline, we need work on three fronts: Firstly, ensure the sustenance of the existing groundwater recharge systems including local water systems & their catchments, wetlands and rivers; secondly, give top priority to creation of more such systems and thirdly, put in place credible, legally enforceable community led regulation. At the same time, the government needs to promote greater access of groundwater to the underprivileged, particularly dalits and other backward classes.
- **Rivers, wetlands and water bodies:** Indian culture and religions are supposed to value Rivers, but our governance system has no value for rivers flowing with freshwater all round

the year. To bridge this serious lacuna, we need a law for ensuring that perennial rivers have freshwater flow all round the year, sufficient for various purposes including groundwater recharge, social and environment needs. Similarly we need law for protection of wetlands, water bodies and catchment of water bodies. We also need to declare some of the river/ tributaries in each state as NO GO zones, where no dams/ barrages/ hydropower projects are allowed.

- Given the link between forests and fresh water flows in rivers, there is an urgent need to take up catchment area eco restoration of at least the highly degraded river basins as a long term strategy; such restoration would also help the cause of climate.
- There is also a need to have comprehensive, credible assessment of basin wide potential of water resources development through watershed development, groundwater recharge, local water systems. Such systems are efficient in harvesting rainwater, in ensuring groundwater recharge and are in fact more appropriate from employment generation point of view. Such an assessment does not exist for any basin; it can be started with say Ken and Betwa rivers basins. In the context of climate change, such options should have top priority.
- Local water systems are efficient in harvesting rainwater, in ensuring groundwater recharge and are in fact more appropriate from employment generation point of view. Such systems, through examples like Hirwe Bazar in Maharashtra, Laporia in Rajasthan and numerous other places, have shown that they are the best adaptation measures even in the climate change context.
- **Agriculture** Organic farming practices must be incentivized, chemicals based farming dis-incentivised. Increased organic matter in soil will also increase the water security for the rain-fed farmers, since it will help increase the moisture holding capacity of the soils, in addition to having mitigation effect from climate perspective. Water saving, high yielding and low input requiring practices like the System of Rice Intensification should be taken up in right earnest at all the appropriate locations, including North West India. **In fact, SRI can be of immense help in the current situation of uncertain monsoon rains as it would help spread the limited irrigation water over long distances, reduce the crop maturing period and reduce seed requirements by upto 90%.** Water intensive crops and cropping methods should be discouraged.
- **Urban areas** Big cities are increasing going farther and farther away for tapping water resources for its seemingly insatiable thirst. This is not sustainable, equitable or climate friendly. Cities must be made to use its available local sources, including rainwater, local water bodies and groundwater in a sustainable way, the waste water must be treated to recyclable level and a cap must be put on how much water they can get. The massive Renuka dam on Giri River in Himachal Pradesh, being proposed for the water requirement of Delhi, is an example of inappropriate water project for an already water rich city. For example, the Planning Commission document *Integrated Water Management Policy and Actions* dated May 2009 says, “Delhi, for instance, has more water per capita than Paris.”
- **Decentralised waste water treatment** Decentralized waster water treatment facilities should be the norm. The decentralized systems would also be less energy intensive, less cost intensive, more efficient and is actually likely to lead to more recycling of the treated water.
- **Mainstreaming Climate Change** The environment impact assessment and decision making process of the water reservoirs in India should include an assessment of the possible impact of climate change on such projects and also the possible contribution of such projects to climate change, including the assessment of methane emission from such projects. On this last issue, India should take up a study of methane emission from existing reservoirs. In the decision making process, relative carbon footprint of different water options should also be an issue of consideration.
- **Approach** The approach towards water must not be a purely supply side response, in any case not through more large projects. Equity and access to water for all through rights based regime and democratic, bottom up, management must be a central plank for any plans.

- **National Water Policy** For the formulation of a new NWP, a detailed participatory exercise should be started immediately. The NAPCC recommends such review only in consultation with states, but this has to be a bottom up, participatory process.
- **Priority for Maintenance of existing infrastructure** Make available adequate funds in the budget as a first priority to maintain the existing water related infrastructure before spending money on new schemes. For example, there is a need to ensure that water bodies, reservoirs and canals do not get silted up and therefore there is a need to make adequate investments for catchment area treatment of existing large, medium and small dams and also for regular desilting of canals and smaller systems. Similarly maintenance of the canal infrastructure to ensure optimum use of created infrastructure should be given a top priority. To ensure that all this actually gets done in a transparent and accountable way, the governance in water sector will have to be changed so that the local people have decisive say in planning, decision making, implementation, and operation of the systems.
- **Weeding out unviable ongoing projects** There are a very large number of ongoing big irrigation projects, many of them are non viable or amounting to zero sum game as the basins or sub basins where they are situated are already over exploited. They are a drain on the economy & there is a need for a credible, independent process to ensure that unviable & undesirable projects may be weeded out or scaled down appropriately.
- **Environment Impact Assessment** Our EIAs are notorious for numerous fundamental failures, including blatant plagirarism, falsehoods, and inaccuracies. Firstly, the EIAs must be made available to local people in their languages. Secondly, all large dams, irrigation projects, flood management projects, hydro projects above 500 KW must go through the EIA and public hearing process.
- **Lack of integration across NAPCC** There is no attempt to ensure cross sectoral integration across the various parts of NAPCC, missions and development path. Thus while the mission for Himalayan ecosystem talks about the vulnerability of millions in mountain environs, the ongoing and proposed initiatives on hydropower projects and the infrastructure that comes along with it is not only threatening the lives and livelihoods of these people, it is also hastening the process of glacier melt through direct impacts, through change in climate in the mountains and also through some local positive feedback mechanisms. Similarly, the initiatives on thermal power projects and mining (including coal, bauxite) proposals are threatening the water resources at numerous sites. The inappropriately undertaken massive agenda of road construction in mountains is cutting of local water streams, which are local people's lifeline. Inappropriate mining is destroying both surface and groundwater. There are no policies for appropriate citing of industries, considering the situation of land, water, forests, and climate implications and so on.

We would be happy to meet you to explain this further, if necessary. Thanking you for your attention, we look forward to your detailed response.

Yours Sincerely,

Endorsed by:

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Paras R. Pujari, National Environmental Engineering Research Institute (NEERI), Nagpur

What is the existing knowledge-base for climate change in the context of water resources in India?

The impact of climate change vis-à-vis the water resources of India have been studied by different researchers in a semi-quantitative and quantitative manner. Studies have been initiated on projected climate changes using Global Climate Models (GCMs) and Regional Climate Models (RCMs) during the 21st century. Generally, all models have shown changing patterns in rainfall and an increase in temperature (Bhaskaran et al. 1995; Lonergan, 1998; Lal et al 2001; Rupakumar et al, 2003). The consequences of increasing run-off leading tosea water rise have been dealt as well (IPCC 1992). A case study in Orissa and West Bengal (IPCC, 1992) estimates that 1 meter sea level rises would inundate 1700 km^2 of predominantly prime agricultural land. In another study (Report from JNU, 1993), it was found that rise of sea level by 1 meter will be likely to affect a total area of 5763 km^2 and put 7.1 million people at risk. Apart from the inundation of agricultural land, the likely intrusion of sea water will deteriorate the quality of coastal aquifers. Studies carried out by NEERI and CMRI (Pujari & Soni, 2009) indicate that the coastal aquifer Saurashtra coast has been affected significantly by sea water intrusion with the TDS in some groundwater samples varying in the range of 3000-4000 mg/L.

Numerous studies have been initiated and the consequences of climate change on variables like rainfall, evapotranspiration, surface run-off are being examined. These studies are still at infancy and more data in terms of field information need to be generated. Tangible results can come out if only the issue is tackled by a consortium of institutes working together with focused goals.

What is the existing capacity in India to understand climate change, impact and adaptation issues?

Climate change has been a topic drawing considerable amount of attention in the last 2-3 decades. It has attained much more attention recently. The problem is being attended by different scientific workers in their own domain. We have national institutes like, CWC, NIH, IMD which are working exclusively on primary data generation pertaining to water resources and meteorological parameters like temperature, daily rainfall, evapotranspiration, etc. We have advanced centres with state of art computational facilities like C-MAACS. The existing capacity in India has the capability and intellect to understand climate change, its impact on water resources and adaptation issues.

(i) Specific research areas and capacity building needs

Climate change is a wider issue and it concerns different sectors like water resources, agriculture, meteorology, hydropower etc. Hence, any study dealing with climate change can be initiated by involving all the sectors likely to be affected by it. However, research can be oriented on the following lines.

a) Initiating a network of institutes/centres to work the problem.

b) The problem should be tackled on basin/sub-basin wise.
c) Creditable primary data should be generated.
Suitable timeframe be fixed to come out with tangible findings. The specific research areas which need focused research are as follows.

The Specific research areas with focused goal are as fallows

a) The focus should be on two basins with wider implications on the water resources. One basin can be the Ganga basin and the other being a basin from the Peninisular India. The impact of climate change on the food production to be studied.
b) The temporal variation of the run-off to the sea should be studied. A typical basin on the western coast, preferably Saurashtra coast should be studied. The choice of Saurashtra coast is in view of its economic importance as the coast is bounded by limestone mines.

(ii) Climate change is a wider issue, thus regional cooperation and collective action are imperatives. Apropos, what should be the "regional responsibility" of India in South Asia (seso-stricto) to combat climate change and facilitate adaptation?

In view of its preeminent position in South Asia, India should be in the forefront of espousing the cause of the developing South Asian countries in combating the climate change. The fact that the present scenario is largely a creation of the developed world needs to be spelt out explicitly in different forum by India in the meetings of SAARC countries. The per capita contribution of South Asian countries to the GHGs is meager when compared to those of US and EU. Hence, cuts in emissions should not be imposed on India and the South Asian countries when development is essential for their national growth. Countries likely to be the worst affected due to climate change like Maldives and Bangla Desh are also in South Asian Region. This issue can be an important discussion point in SAARC summit and a common memorandum can also be prepared. India can lead preparation of this document particularly adaptation strategy for the region in general and the worst affected countries in particular.
However, shouldering "regional responsibility" may not be easy and consensual considering political differences in the region.

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Devendra Sahai, Global Warming Reduction Centre, New Delhi

I firmly believe that most of our problems relating to the environment are due to the explosive growth in population since 1947. An optimal balance between population, resources and environment (or the ecosystem) is essential for sustainability. A population overload beyond the

finite carrying capacity of the ecosystem and the resources available, leads to destruction, degeneration, pollution and eventual elimination of the latter two. Hence, it is imperative that we focus on first stabilizing our population and then reducing it to a sustainable level. That in my considered opinion is not more than 70 crores for India. This vitally important subject has been criminally neglected while we have focussed on our worsening Environmental problems. You cannot cure a patient without clearly diagnosing the root cause and then addressing it sincerely and with firm determination. Please may I request you to include this aspect for debate in the Seminar. I enclose my article on the subject (http://www.solutionexchange-un.net.in/environment/cr/res01070901.doc, DOC; Size: 55KB)

Prasoon Shukla, DBS Post Graduate College, Kanpur

In India the Ground Water Commission needs to strictly implement rainwater harvesting, which it not doing now. It has been made mandatory for every department, businesses and residences to have a rainwater harvesting system but no guidelines have been issued, and there is a shortage of skilled people in the departments concerned. Only by harvesting rain water properly can we overcome the problem of depleting fresh water resources.

We must develop volunteers to help proper installation and maintenance of rainwater harvesting systems. NGOs can offer this work to private companies. Likewise, we must reduce the dependence of our electricity generation on the natural resources of the state, because different states of India have different potential natural resources. We must introduce the concept of harvesting volunteers to students of universities to give them an exposure and get the work completed as part of their project activity. We should encourage quarterly analysis of our groundwater resources because only after that we can decide our strategies for the next quarter.

Arun Jindal, Society for Sustainable Development, Karauli, Rajasthan

Climate change is an inevitability that occurs regularly in our life and livelihood. We at SSD have adopted rainwater conservation and management in Daangs area of Rajasthan. This area is rocky and undulating. Villagers conserve water in ponds locally called it "pokhers" and use water for irrigation. SSD has supported revival and new construction of more than 200 pokhers and all structures are useful for irrigation and groundwater recharge. Villagers use gravity for irrigation so there is no need of electricity. The southern, eastern, and north-eastern parts of Rajasthan have the same topography and this structure can be utilized for climate change adaptation.

Neelima Garg, Uttarakhand Jal Sansthan, Uttarakhand

The Uttarakhand Jal Sansthan is studying the effects of climate change, seasonal changes on the discharge of its sources (springs and gadheras) in various districts of the State.

Number of Schemes where discharge has decreased more than 50% in last 3 years

S. No	District	50%-75%	75%-90%	Above 90%	Total
1	Dehradun	6	4	2	12
2	Pauri	26	120	39	185
3	Chamoli	15	9	-	15
4	Rudraprayag	12	-	3	15
5	Uttarkashi	10	2	1	13
6	Tehri	22	47	20	89
7	Almora	11	25	10	46
8	Champawat	7	35	12	54

9	Bageshwar	3	3	-	6
10	Nainital	18	7	-	25
11	Pithoragarh	9	16	6	31
	TOTAL	139	268	93	500

It is obvious from the above table that the discharge from 500 sources of water has decreased more than 50% in last three years.

Ajit Seshadari, The Vigyan Vijay Foundation, New Delhi

We wish to introduce ourselves with well-wishes, as a NGO, the Vigyan Vijay Foundation, working on watershed development with implementation elements in both rural and urban sectors. Our inferences on climate-change and water resources are given below:

1. The sources of fresh water are surface water in the form of rivers and lakes and groundwater.
2. In India surface water is getting depleted due to pollution and ground water is getting over-exploited. For example, the Bhadkal lake of Haryana has completely dried up due to mining. Groundwater at few sites was found to have high TDS in ground-water in range of 1500 to 4000 in Haryana, due to over-extraction. This year due to delay in monsoon showers three power stations namely: Bhakra Nangal, Tehri Dam, and Narmada Dam, were affected. Water level in Bhakra Nangal Dam went down considerably with nearly 50% shut-down.
3. Glaciers' conditions are even worse; 'Gangotri' glacier has been estimated to be retreating at rapid rate. Climate Change is inevitable even if all the emissions are stopped today. But we can do our part in slowing the process.
4. Along with mitigation, Climate Change Adaptation strategies are the area of concern today. A few NGOs in India are working on the same. Many companies take up CDM projects as CSR activities and also do plantation drives, but it will be good if they could sponsor research and development too.
5. Climate Change is affecting water resources and the hydrological cycle, but our concern to halt over-extraction.
6. Pollution of water resources is another priority. These two problems together are leading to increase in natural disasters. One more example could be that the lowering of the water table also leads to drying up of top soil which will result in easy uprooting of trees during storms. Also some inference can be drawn from the quake-tremors in Ahmedabad, Gujarat, on the effect of tremors observed in relation to aquifer-levels in relation to high-rise buildings.
7. Here the study extends to hydro-seismology. It has to be dealt with carefully. One topic of study can be whether the soil moisture and its resilience properties can cushion seismic tremors. This can be studied with previous experiences.
8. In our experience, we cite a few of the options / initiatives to the problems:
    a. Rain water harvesting for groundwater recharge and, similarly solid-waste, i.e., organic waste from kitchens can be used for composting and producing manure and bio-gas
    b. Waste-water reuse after treatment to the extent that it can be re-used for lower-end uses, viz., landscaping and washing. Adopting plans like waste-water reuse and recycling will help in lowering the load on fresh-water, since it is a way to convert 'waste to a resource' and also reduces emissions
    c. We in association with IIT- Delhi have experimented with urinals and set up a plant that collects urine and provides manure for gardens through an underground pipe-line; it has given positive results. Such initiatives for landscaping are very beneficial as they improve the local climate of a place. Also

the waste-water gets phyto-remedied through plants before reaching the groundwater

d. Solar-power generation is gaining attention and if considered, this is substantial way to cut down a major amount of emissions
e. Also to control water-pollution and water-borne diseases, traditional and new techniques of eco-sanitation might be adopted. Eco-sanitation aims to capture and restore the nutrients in human urine and excreta ploughed back to the soil in localised areas

Many of the centralized systems like that of STPs are under or over-estimated. Decentralized implementation for such innovations with community participation may prove to be more effective and beneficial, and hence decentralization of these initiatives needs to be promoted.

Dealing with Climate change and water-depletion or water-insecurity at the grassroots is as important as technological improvements, appropriate planning and, adopting traditional knowledge. Environmental communication is lagging, and this can be addressed if NGOs and the media work together. A lot of NGOs are running Green School Programmes, which equip schools and institutions to audit their premises and find ways to cut-down their ecological footprint. More such programmes will help in grassroots awareness. The government's support is needed in forming proper policies and ensures effective implementation.

It is suggested the workshop also needs to address the role and importance of environmental communication, adaptation technologies that can be implemented, decentralization initiatives like waste-water treatment for landscaping purposes, and community participation. It should explore how the solutions can be achieved, what are the loopholes in policies and implementation and how can they be overcome for sustaining a level of quality living in communities.

Binukumar G. S., Institute for Resource Analysis and Policy, Hyderabad

Our climate change issues and debates over its studies and results have been going on for long. Everyone has provided information on the impact of climate on the environment, and is trying to find solutions. I think it is a good initiative from the members of Solution Exchange.

My question is, who is responsible for this climate change? Nature, human beings, animals. Who is the culprit and who should start to stop this climate changing?

Of course, there will be several reasons for this climate change, but one of the main reasons is the activity of human beings. Being a social worker I am very much concerned about this. Most our members have said they have collected information about climate change from village people. I wonder if people living in cities have anything to say about climate change. Are they not aware about climate change or its impacts? Or are they not a part of this.

Almost all of us are in urban centres and talk very seriously about climate change. From my little knowledge, excessive use of electricity, air-conditioning, civil works, vehicles, over-exploitation and misuse of water, deforestation, removal of trees for urban development and industrialization are the most important factors of climate change. The so called westernization, modernization and luxurious life of urban people, especially the youth, are adding fuel to the fire. Are these people not aware about climate change and its impacts on the environment?

We are spending time to learn from the village people, and teaching them about its pros and cons. So what about urban society? Do they a special privilege to ruin our environment for their comfortable lifestyles? What is their role in these activities? Who will start to create awareness about climate change and its future impacts?

"Prevention is better than cure"; so we should spend some time to think about this social awakening process for minimizing the climate change impacts.

Himanshu Thakkar, South Asia Network on Dams, Rivers and People (SANDRP), New Delhi *(response 2) **

The information provided by Neelima Garg is indeed very interesting. Can you tell us if this reduction is on annual basis or some specific period? Secondly, at what location/s is this reduction observed, that is in the path of a stream the % reduction would be different at different locations; hence locations are important where this reduction is observed. Thirdly, the reduction is with respect to average flow over certain years proceeding these three years, I guess, so it would be useful to know for how many years flow average is used for this. I guess all these are glacier fed streams? Is it possible to know the names, river basins of these streams/schemes? Is there is a study that one can look at?

** Offline Contribution*

Many thanks to all who contributed to this query!

If you have further information to share on this topic, please send it to Solution Exchange for the Water Community in India at se-wes@solutionexchange-un.net.in with the subject heading "Re: [se-watr] Discussion: Research on Correlation Between Water and Climate Change. Additional Reply."
