Notes of the sessions of the Open Science Seminar
Future of Water Resources in India under a Changing Climate

13 and 14 of May 2009,
TERI, New Delhi, India

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Note for the reader.
These notes are a rough reflection of the presentations and discussions of the different sessions. Most of the presentations are made available on the HighNoon website. To fully appreciate the text, it is recommended to read the notes together with the presentations.

13 May 2009

Opening Session

Chair: **Eddy Moors**
Reporter: **Christel Prudhomme**

Ashok Jaitly, TERI
Water resource in India is a National and regional Agenda: seminar very timely.
Currently: water crisis in India, already happening, and increasing due to increase in demand and poor water management (resource is large but taken for granter). Now situation very difficult and alarming, due to increase in demand : population, agriculture, industry, economic growth (higher leaving standard): demand has increase exponentially.. At same time, water resource is finite: problem.
Serious regional in balance.
Needs more effort in water management and efficiency of water use.
Addressing water crisis… demand management approach advocated including economic measures as well as regulatory measures, policies, often populist, contradictory to sustainable management (e.g. subsidies to fertilizers, free electricity

encouraging over-pumping – agriculture policy)… need for institutional reform. The two aspects: water demand management, and institutional reforms.

Climate change is on top of that and might make it worse: Glacier retreat threat to water res'; sea ingress affecting g'water, water supply;
Insufficient data for policy formulation; need also for local/basin/regional-level scenarios and modelling; for developing appropriate adaptation strategies. Must be done at the whole of South Asia, through international cooperation and data sharing. Data gap is critical.

Q (?TERI): What do you mean by inst reform
A: 7 ministries resp for water management; no consistent legal framework

Q (Karki): Role of China?
A: Agree China important for Indian water resources: TERI working with India-China Cooperation

Daniele Smadja, Head of EC Delegation to India
Described Framework Programme, largest research framework in the world, support to EU policy development. Strategic partnership with India, hold annual meetings at highest level, and have developed joint action plans help buttress partnership… wide-ranging fields, with progress reported at periodic summits. EU & India recognize key role of S&T dev in addressing sustainable development, including such areas health, food, climate change and environmental management. 68 projects funded so far, 22 fellowships… examples of very young partnership…good start, huge potential for further investment. EU-India science cooperation, initiatives coordinated calls inv investment from both India & EU 8M EU so far in 2 calls, future calls planned in renewables research, water and water treatment, and health. Delighted to see HighNoon reinforcing relationship between EU & India. Pleased to see synergies between HighNoon & WATCH, further strengthening EU cooperation with India.

Tasos Kentarchos, EC Climate Change and Env Risks Unit
Described background of HighNoon, EC DG-Research workshop (8-9 Feb 2007) with objective to bring together leading scientists and decide priorities for research on climate change… Himalayan glacier retreat identified as topic of high scientific and societal importance.
Resulting call in 2008, for Specific International Cooperation Action, received 9 proposals with HighNoon receiving highest score in its call and second for all climate-change related calls.

Pleased to see HighNoon joining forces with WATCH, an important programme for EC addressing problem of water resources, floods and droughts under climate change. Both needed to provide solid answers to policy makers. Collaboration with Indian institutes is a future aim, to improve knowledge transfer.

Stefan Agne, EC DG-Env
Climate change negotiator, outlined 5 key policy issues for Copenhagen…described Copenhagen Communication outlining EU position with respect to the future negotiations, offering emission reduction of -30% by 2020, a target for other developed countries too; recognise emissions from developing countries will need to

increase, but recommend a less rapid growth, of 15-30% below business-as-usual based on low carbon development strategies. Described McKinsey (2009) cost curve identifying profitability/costs of different strategies/options and outlined different measures (e.g support actions) that might be used to implement. Need for capacity building, technology-oriented cooperation, infrastructure development.

All countries need to adapt, EU suggesting whole range of measures to adapt and have recently published White Paper on Adaptation… most importantly advocates need to work with developing countries on adaptation. Carbon market mentioned as possible measure for mitigation.

Climate change on top of policy agenda for EC.
EC wants to work with DCs to reduce emissions
EC wants to work with DCs on adaptation: several EC measures (programmes, partnerships), encouraged R&D programmes to work with these.
Need to translate policy into real actions!

Glacier and snow melt in the Himalaya

Chair: **Sanjay Tomar**
Reporter **Jan Haerter**

Eddy Moors, HighNoon
Project addresses problems of glacier melt and changing monsoon patterns…
Link to WATCH.
Need to improve climate forecast skills at regional scale, and integrate socio-economic drivers… improved understanding will help develop appropriate adaptation strategies
Expected outcomes: improved knowledge of glacier melt, glacier lake formation, cc affecting monsoon patterns, impacts on water resources… tools for prioritisation of adaptation measures; indicator framework to help policy makers, etc..

Ref "Mass loss on Himalayan glaciers endangers water resources" (Kehrlwald, et al 2008, GRL)

Q: Objective for new tools for research – are existing tools adequate?
A: Modelling tools will be improved, socio-economic side especially & involving relevant stakeholders.

Q: How are other organisations to be involved (e.g. in HP, extensive database has been developed on glacier retreat and modelling undertaken)…
A: Very pleased to involve organisations that have relevant data; discuss later

Q: Project include downscaling approaches?
A: Yes, will involve local scientists on such work

Richard Harding, WATCH
Large IP funded by EU – 10M Euro, 4yrs, 25 partners.
Many cc impacts are related to water… incl extreme events, floods and drought

Large areas of the wirls, incl India, where models disagree on projected precipitation changes; better agreement with T.
Generally it is thought dry areas will get dries, wet areas wetter
WATCH to assess uncertainty in projections, improve models… objectives… products.
Regional studies… Europe and northern India, latter scientifically challenging and important socio-economic issues.
Described inter-model comparison work; presented results for Ganges basin analysis.
Will deliver: consistent driving data; improved global hydrology/land-surface models; estimates of uncertainty; new analysis for water resources for 21st century
Developing strong links with HighNoon in India, working to ensure outcomes of both projects are properly linked to policy and stakeholders.

Q; Study addressing f&d at what scale: whole India or basin-wise?
A: Globally, whole world at grid res; also in basins; Ganges basin in India

Q: WWF e-flows modelling of Ganga basin with IWMI, incl env flow modelling
A: Very much look forward to making links with such projects

Madhav Karki, Glacier and snow melting in the Himalayas and its possible impliations…
Sees complementarities and synergies with WATCH/HighNoon and work of ICIMOD.
Described national/regional trends in glacier melting: 1.3Billion rely on water from mountains in HKH region. Would like to enhance understianding of change and work with partners on how to adapt. Deglaciation happening rapidly all over Himalaya, e.g. China, Bhutan, Nepal; most data show fluctuation at terminus, v little data on volumetric/mass balance changes… need improve this, need better data.
Landsat/ASTER images show reduction in snow and glacier cover.
GLOF threat increasing due to melting of permafrost. Using reomote sensing to identify glacier lake formation and assessment of GLOF risk.
Tincreas at higher elevation far higher than at lower elevation, glaciers retreating more rapidly than anywhere else, high popltn affected, knock-on effects to forestation, land-use change, etc., changes to water res availability, possible that GI&B rivers may become seasonal.
Glaciers good indicator of CC
Regular monitoring reqd
Monitoring glacier lakes reqd
…for better understanding of regional cc
… need international/regional collaboration to improve understanding
… need better planning of water resources to mitigate future CC impacts, nationally and internationally
ICIMOD programmes incl Monitoring of Cryosphere
Implications of glacier melting
Outline ICIMOD activities

Q: Were all glaciers retreating? Some advancing in Sikkim… when quoting retreat, are figure on same basis?

A: most retreating in eastern Himalaya; some local effects may be causing some advance.. need to monitor to understand why. Retreat monitored on a consistent basis using DTMs…

Q: Evidence that policy response is reqd; what implaications political situation in NP?
A: Policy makers will start doing something based on sci evidence… need to reduce sci uncertainty; need to reduce risk floods/flash floods… recent Koshi flood raises awareness amongst policy makers; need to raise awareness in policy makers, and consider appropriate measures. Countries more open now to int collab'.

Madan Lal Shrestha, Climate change and glacier retreat in Nepal.
Large diversity in climate over relatively short distances, link to water and water system
Change in T – increasing trend 0.04degC/yr average annual T; winter T increasing more rapidly 0.05 (KTM) – 0.08 (where?) degC/yr- T increasing at higher elevation too. Cool nights decreasing, warm nights increasing.

P change – mapped – post-monsson P decreasing; overall annual P increasing, but rain days slightly increasing; but rain days =>100mm increasing more significantly.

Model output from PRECI suggest wetter (annual P) future over 21centruy, yet drier winters

Impact of Cryosphere:
Increased number of glacier lakes – increase risk/threat of GLOFs
Described Tsho Rolpa lake, and mitigation measures… 3m reduction of lake level
Ngojumba glacier – largest in Nepal – formation of many new supra-glacial lakes
Rain occurring at higher elev, accelerates melt
Described reduction of Rikha Samba glacier 1974-94; AX010 1978-2008
Glaciers in Nepal have generally been in retreat… many examples

Many Nepalese basins contribute river flow to Ganges river system. Tremendous volume of water from mtns to the Ganges.
Water res and hydro vulnerable to

APN project in Nepal on "Impacts of global change…"

T increasing in NP esp at higher elev!

Future challenges: what can we do to mitigate impacts? Better models? Better data, high resolution data (from RS) especially… density of observed stns very low at high elevation… better discharge measurement… investigate relationship between glacier retreat and meteorological phenomena (e.g monsoon); encourage participants to consider APN as source of funding for research in this area.

Glacier and snow melt in the Himalaya, 2nd session

Chair: **Eddy Moors**
Reporter: **Neha Pahuja, Christel Prudhomme**

David Collins, Climate change and runoff from glacierised mountain basins
Long term measurements in Switzerland: good measurements necessary for good modelling. Difficult to get long data series in the Himalayas
Little ice age: long term loss of glaciers. Glaciers are headwater to major continental rivers, modify the runoff regime, with delay of maximum of runoff, but also moderate year-to-year variability. Glacier decline means change in river flow regime.
Schematic of links between volume and area of glacier. What happens now: loss of mass due to smaller rainfall compared to little ice age. When a glacier decreases, variability in flow (CV) increases: year-to-year variability enhanced in spring and autumn.
Data from 1850s for Rhone basin above Lac Leman: glacier covered 17.9% of catchment in 1876 to 14.4% 1973. Large change in area is not always linked to large change in mass. Largest discharge from the little age arguably the 1940s, 2003 flow lower (despite very warm 2003): warmest years not necessarily linked to largest flow. In the last 40 years, the more highly glacierised catchments have seen the largest reduction in discharge.
Question for High-Noon: are the Himalayans glaciers going to retreat completely, and by when? Needs to collect data on glacier runoff, access to river flow data, and improve capacity building.

Q: What about sublimation? Does that happen?
A: Some sublimation might happens, but possibly not a huge proportion. In Tibet plateaus, glaciers are small.

Q: What data you have used to show the shrinkage of glacier in HMK?
A: Not a lot of data. Limited amount of river flow data for several months in the 1990s. No modelling study have been done to simulate the area reduction. It is not sure data exist
A2: mass balance data for the 2000. No work done on this glacier but will be done soon. No remote sensing data. Negative mass balance has been seen in 4 years of data.

Q: Western/East glaciers are different in the HKH. In West: winter temp not rising as fast as in the east. Is deglaciation linked to altitude as there are variation in climate? And what is the influence of evapotranspiration rate.
A: High mountain area with 70% glacier evaporation might be negligible due to small values and condensation. Not the case in Tibet where evaporation is larger. Impact of climate depends on occurrence of Monsoon or not. Altitude will suppress the degree/day but not radiation (which has the same impact at any altitude).

Dr Shresth Tayal, Status of Indian Glaciers under climate change scenarios: an overview
HKH glaciers are vulnerable to increase in temp due to their latitude (near tropics). As well, lack of data means we don't really know what is happening.
Western zone: precipitation in winter, where stay as sno/ice; Eastern zone: rainfall during Monsoon, which increase melting of snow as occurs late summer. Transition zone where Ganges basin is: some precip during Monsoon, and some in winter. The dynamics of glaciers is very different in these 3 zones.

Indus has a large proportion of glacier component of river flow (45%), Ganges and Brahmaputra: only small (10%). This is based on annual discharge, not taking into account monsoon variation: seasonal contribution of glacier can be larger for Ganges and Bramhaputra. Indus and Ganges: about 700 glaciers, less for B'putra. Average size of glaciers in Bputra larger than for Ganges. Volume of glacier is largest in B'putra.
CC projections in south asia, A1B: increase of 3.6 degree DJF, and warming 2.7 JJA, increasing northward. Precip is projected to decrease.
Kolahoi glacier, west; East: Rathong glacier. Monitoring of these glaciers and the runoff is set up. At present not yet chosen glacier for transition zone.
Kalahoi glacier: Using Dem: possible to map in 3 dim the glacier recession since 1965 (loss of 15% of area which is 2.25 km2).
Rathong glacier: Some sublimation is occurring in eastern glaciers. Lake has formed, 0.051km2, blocked by rocks. Since 1966, loss of 93% of glacier (6.6 km2).
Transition: Gangotri glacier. Dye measurements show that it takes 2 days for runoff to come out of glacier during monsoon.
Deglaciation is taking place, at a higher rate in eastern zone than western zone.

Q: Is their any groundwater impact in change in glacier? This is very important for water resource in India. Is it part of the project?
A: Needs to analyse the river flow regime by seasons and by different component (rainfall/ snow melt component). Hope this might be part of the project
Eddy: we will try as important, but that will depend on the data availability and capacity within the project.

Q: We also have seen large decrease, due to using different type of data. But the comparison of different data source might be misleading: are the mapping done in the same way for Rathong, are the results realistic?
A: yes

Q: Volume of glacier is not always well calculated. What factor did you use to change area from volume? This is not always the same depending the shape of the glacier
A: we used published data (2002), and did the analysis. We aim to improve monitoring to check the calculations

Gwyn Rees, CEH, Glacier melt and glacier lake outburst floods
USGS: Gangotri glacier has retreated in the last 20 years as much as in the past 200 years. Throughout Nepal, many examples of glacier retreat. Once consequence of retreat is formation of glacier lake, that can be seen from satellite imagery, closed by moraine. Glaciers lakes are instable because closed by moraines, boulders, sediments: glacier lake outburst (GLOF). Dam can break due ydraulic pressure, earthquakes, avalanches, snow melt. When happens: huge amount of water floods valleys. There are 26 potentially dangerous lakes in Nepal, 30 in Bhutan. Some recent GLOF have occurred, in 85, 91, 98. Not only lakes have increased in numbers, but also the area and volume has increase, making the lakes very dangerous. Example given of 2 lakes in Nepal. The impact of GLOF would be extremely damaging: example of the Tsho Rolpa: mitigation measures have been implemented, such as lowering lake level, but also early warning systems for evacuation of villages. Public awareness is very

important. Risk of GLOF might be increasing with global warming, and it is important to identify the most dangerous lakes and implement appropriate measures to mitigate the impact and reduce the risk of GLOF.
Q: Why not using remote sensing methodologies to map the dangerous situations? Can this be part of the project
A: Probably not scope of HighNoon but should be investigated. Remote sensing is a good way to identify GLOF/ Lakes earlier than conventional techniques.
Identification of potential dangerous lakes needs to consider not only the moraines, but the communities downstream, the geomorphologies etc.. to evaluate the vulnerability due to hazard of break
Q: Needs to establish probability of damming. With remote sensing and modelling, simulation of impact areas and assessment of risk can help establish functional early warning, There is a need for a prototype tool to study that.
A: Mitigation measures are extremely expensive and cost/benefit analysis must be done. It might depend on the size of the community – public awareness might be as good as mitigation when physical measures are costly.

Predicted changes in Indian Monsoon

Jan Haerter, MPI, WATCH – Indian focus region: RCM plans and data requirements

Mr. Jan told to prepare regional climate RCM data with statistical two parametric bias correction what he has already performed for WATCH project. The RCM outputs will be developed from ERA40 and A1B scenarios implemented in GCM with double nesting approach. The outputs will be precipitation, temperature and may be used in the HighNoon project. He asked for 1o x 1o grided data as well as station data (observations) for bias correction. Audience asked him to be clear on bias correction, whether it will be on daily data or on monthly data and he cleared that bias correction will be performed on daily data and then it will be arranged for monthly or any scale required for the study.
Main issues:
Plans for RCM data for WATCH in India: regional reanalysis dynamically downscaling GCM data… ERA40 driven RCM simulations, control simulation, A1B CC simulation. Downscale GCM to 0.5deg and then to 20km. GCM forcing ECHAM5 and HadCM3, using REMO for downscaling. Analysis of different RCMs in Ganges/B'putra, Godavari, Mekong & Upper Indus. Significant discrepencies between models an issue of concern… need more accurate obs data.
Issue #1: need better observational data!
Statistical bias correction: hydrological models cannot be expected to give acceptable results with unrealistic forcing from climate models. All aspect of field stats need to be corrected (frequency, mean, variability). Bias correction needs to be robust… 2 parameter fitting between modelled and observed. Bias correction works remarkably well.
Issue #2: need local observational data
P & T not independent! … bias correction needs to take this relationship into account.

Q: Models of total P in Ganges/B'putra appear to underestimate observed data. Beware IMD data gives higher values than CRU data.

Q: Have models been used to est daily P?
A: Yes, model generated daily data over 10yr period 1990-99, aggregated values presented seasonally, annually.

Q (Fulco): considered rain days
A: yes

Comment: suggest models at any particular resolution should be resolved at finer res in mountain areas, to account for orographic effects
A (RH): big challenge for climate modellers.

Jeff Ridley, Met Office, Glacier runoff in a global climate model
Mr. Jeff showed the simulation results of JULES- Land Surface Model and Andes Glacier models simulating the consequences due to changed climate and glacier melt. He estimation showed that sea level has risen 20 cm since 1800 AD due to accelerated glacier melt and it may lead to less availability of fresh water in watersheds. He showed results that some glaciers are disappearing 10 times faster than they did just 20 years back and thus will disappear soon completely. Finally he concluded that glaciers will be major source of sea level rise in 21st century and rise in temperature, precipitation and runoff will result in regional differences in glacier behaviour.
Main issues:
JULES – Land surface model simulates surface exchange of heat, water, momentum and carbon, dynamic vegetation model (TRIFFID), used in Hadley Centre climate models. JR own interest ice contrib. to sea-level rise. Glacier contrib. to SLR since 18centruy is about 20cm.
JULES – glacier component being developed, part of Catchment Water Resources, based on approach by Sarah(?).Marshall (Canada, date?) where for each GCM grid-box hypsometry of the gridbox described ice melt according to lapse rate. Tested in Andes, applied SRES A2 scenario in HadCM3, to assess relative change in future ice volume. Increase resolution/reduce grid-box size improves representation down to 100km.
Glaciers major contrib. to SLR during 21century
P, lapse rate & T adequate to estimate impacts at regional scale.

Q (Fulco): on SLR, figures presented lower than general predictions?
A: no consistent with others, includes Greenland

Q (Madan Lal Shrestha): shouldn't higher resolution representation required in Himalaya ?
A: Validation based on observed data

Q (DNC): model internally consistent but not represent reality, how catchment represented?
A: catchment represented as relevant cells, observed data can be used to validate
A:(RH): cell resolution broadly indicates flow direction of rivers, means obs data can be used.

Pankaj Kumar, MPG, MPI-M input to HighNoon and monsoon in REMO

Under his talk he presented the role of his institute in HighNoon as the first part. Basically he has given his work plan with deliverables and informed that based line simulation 1960 to 2004 may be delayed by 2 to 3 month due to change in MPIM computer setup. In this second part of the talk he represented MPIM regional model REMO simulation over South Asia with a focus over India. The simulation results of REMO showed it as a power full tool for monsoon simulation and may be used for climate change and adoption studies. Audience raised query about physics of REMO model handling convective scheme or schemes and Mr. Pankaj informed that at present REMO has only one convective scheme and has plan to add more schemes in future. Another query was about REMO simulation results on temperature - showing high over Indo Gangetic Belt and high precipitation over NorthEast India and Western Ghats. In his reply Mr. Pankaj agreed that REMO has simulated high temperature over that region by 1-2 o C and also has a hot spot over north east Pakistan and they are still working to improve the model. Regarding precipitation he told that if results are compared with CRU then it will be less because CRU has less observation station over that region. However, in comparison with IMD data the results are fairly well over both the regions.
Main issues:
Will require intrinsic glacier function to be developed in MPI RCM to forecast runoff in Himalayan region.
Validtn data, from IMD...
Ref (Rajeevan et al., 2006 Current Science)... cf CRU, CRU not very good esp in Himalayan region!
REMO output (summer JJAS rainfall)compared with CRU and CEMAP… well simulated! Max temp similarly well simulated cf CRU… albeit REMO hotter over NW India- Punjab, etc…
A1B sceanrio v control, 2070-2099 cf 1970-99 (ctrl), decrease c.20% of P in Central-North India, increase in peninsular India… general increase in T!

Q: Consider other scenarios than A1B
A; no

Q: Some inconsistencies between REMO and output (rainfall, T) from PRECIS model (esp in SE Coast and NW areas), latter cf well with NCEP data…. Weak in mtn areas?

Q: REMO model same physics ECHAM and other RCMs?
A: Same physics in ECHAM/ERA (don’t understand Q or A!)

14 May 2009

Impacts on the hydrological cycle and water resources

Chair: **Sanjay Tomar**:

Gwyn Rees, Impacts of glacier retreat on Himalayan water resources

- Project 2001-2004
- Worldwide problem of glacier retreat
- Motivation: "All glaciers in central himalaya could disappear by 2035
    - Series of catastrophic water shortage
    - Led to proposal
- 0.6 deg/year temperature increase in Nepal
- Highest gauges: dramatically higher increase (0.1 deg/year)
- Could explain rapid retreat
- Assessing impact on water resources: macro-scale glacier melt model, incorporating first regional glacier melt model
- Baseline estimate of water resource availability, used CRU to estimate runoff
- Applied variety of climate change scenario
- Developed 'what-if' scenarios, also used hadrm2 model data as input
- Results: within distance of 90km the impact reduces significantly, when you get down to Indian-Nepal border, the impact is not that hard-felt for deglaciation
- In the Indus the situation is quite different: here very little run-off is generated in lower area, reliance on melt water from glaciers here.
- Pakistan has stronger glacier retreat in 0.6 deg/y scenario than Nepal
- Flows in Nepal can actually increase vs. Pakistan
- **Conclusions:**
    - Impacts of deglaciation Differ from east to west and within catchments
    - Highly glacierized catchments are most vulnerable
    - Variation in precipitation is important factor
    - Blanket effect and mitigation of downstream impacts
    - Rivers in humid east probably less susceptible than those in arid west
    - Some areas could benefit from increased water availability, many others may suffer significant reductions
    - Unlikely that all glaciers will vanish by 2035.

Ashwin K. Gosain, Climate change impacts on the hydrological cycle of Indian river systems

- Methodology: use HM to quantify impact of climate change on water resrouces
- SWAT model (IIT Delhi)
- All major river systems were modeled as virgin systems
- Modeled almost all major systems of the country
- Data used for modeling: model data from hadRM2 from IITM, Pune
- River basins modeled: ganga, brahmaputra, Indus, ~10 other Indian rivers

- Showing results for ganga and brahmaputra, P, T, RH, soil, relative wind speed
- Cannot use monthly data, hydrology will be lost
- analysis: changes in magnitude and frequency of flood peaks, severity of droughts, changes in flow patterns, changes in groundwater recharge
- vulnerability assessment procedure: palmer drought index, PDSI value, soil moisture index
- **Ganga sub-basins**: most show increase in total number of drought events
- Monthly water balance components for ganga river basin:
    - Precipitation: some increases of precipitation in july/august
- flow duration: increase in low flows, slight decrease in high flows.
- **Brahmaputra basin**: one station available -> validation of hadrm3 using the observed flows at pandu
- **HadRM2**: definite increase in precipitation for A2 scenario, snow fall decrease, increased snow melt, increased surface run-off
- **Conclusion**: Need to incorporate glaciers, mapping and incorporation of present manmade interventions, re-evaluation of the hot spots, generation of coping strategies and scenarios

Questions

parameters difficult to estimate, confidence intervals in results?

- "There are checkpoints in the models such as the flows"
- If the model is reproducing every component equally well, we know that the model is doing the right thing

Initiative: National database infrastructure, network data bases, how the entities can be put together and stored in a central place.

Christel Prudhomme: Assessing changes in hydrological extremes under climate change: Methodologies in WATCH

- WATCH WB4: frequencies, severity and scale
- Concentrating on large-scale and regional floods, no localized floods
- Drought: meteor. Drought, hydrological drought
- 2 examples of indices for drought/flood:
    - Flood: peak flood over threshold
    - Drought: drought event lower than 90th percentile of season
    - So far focused on current day Europe, but want to extend to future drought assessment
- Does a flood or drought always occur under similar synoptic conditions?
    - Compared frequency of weather during flood day and any other period.
    - Frequency anomaly of weather type: low pressure in north, high pressure in south
    - For drought: similar methodology
    - For drought: correlations maps
- **Conclusion and Outlook:**
    - Indices define to analyse extremes
    - Evaluaton of remaining bias in 20th extremes
    - Comparison of extremes for 20th and 21st century
    - Analysis of future weather type frequency

- Work outside Europe and hopefully India

- **Questions**
  - Discussion on correlation with weather anomalies

Impacts on the hydrological cycle and water resources, 14 May, 2nd session

Chair: **Eddy Moors**
Reporter: **Catharien Terwisscha van Scheltinga**

Fulco Ludwig, Obbe Tuinenburg, Ronald Hutjes, and Hester Biemans, Wageningen University and Research Centre, Netherlands
Irrigation feedbacks on the climate system

Worldwide water use by sector and continent, most used by agriculture, especially irrigation. For Asia, it is predicted that over the coming decades irrigation water use will increase. Feedbacks between irrigation and rainfall patterns are expected. Several studies have indicated that soil moisture can affect the local climate. India has been shown as one of the three hotspots indicating soil moisture / atmosphere relationships (models without irrigation). Feedbacks are likely to occur (positive and negative), and work in progress was presented. Feedbacks over India precede the onset of the monsoon. Irrigation in these areas could influence the monsoon onset. Current research related to this question was presented. There is a negative correlation between rainfall and NDVI (representing irrigation during monsoon). Reduction of July surface temperatures, possibly as a result of increased evapotranspiration. Need to further test these ideas (interdependence or not?), to run climate models with and without irrigation. However, global change is likely to alter the feedback. In some seasons, glacier melt is the most important part of runoff, so changes will alter runoff considerably. There is the need to combine different models (climate change impact models, no feedback loop from irrigation via evapotranspiration to rainfall). Problem of matching the different scales (time and space). Importance of LPJmL global agriculture, vegetation and hydrology model.
Remaining questions: to quantify the feedbacks, and to indicate how they change in a changing climate, test the inclusion irrigation in the climate models, and whether that will that change the predictions.

Q (Jeff): One way to test self-precipitation is to find Hydrogene and oxigin ant…. (one per country at least). Albido effect (no vegetation) can also be used.
A: Albido does not necessarily show irrigation.
Q (ECHO): what is the effect of evaporation and transpiration. Subcontinental cooling?
A: Local cooling rather. We look at what ET is doing. We did not do an experiment on the albido effect. It depends on crop there – and whether you'll irrigate or not and e.g. a vegetated area, or whether you create a new irrigated area in an earlier dry place (e.g. Egypt)

Richard: No doubt that wetting of the soil has effect on ET. Drip irrigation might show different effect.
Q (NL Science and Technology): Demand for new technologies to water crops, to reduce the amount of water used by irrigation.
A: When there is irrigation – people overuse the water. There is population and water use per person. Both increase. In Europe both are stabilizing. Q: those impacts to be included in the models. Reduce irrigation and make it more efficient. A: Agreed.
Q (Kumar, MPG): hotspots for feedbacks. Elaborate what was done.
A: Models compared with observations – and different soil moisture – and then looked at differences. Q: I always had better results at dry soils. A: this is not absolute. Q: but in India, the hotspot should not be there. A: It might be good to compare how your model fits in with the 50 models used.
Q (Kumar, MPG): asks clarification on July precipitation trend (slide). A: refers to paper.
Q : NDVI was used, which does not always represents irrigation.
A: correct, but in March-April-May period it does.
Q (David): relation between snowcover and precipitation. Might run in parallel.

Sanjay Tomar, TERI, India
Creating Adaptive Policies - A Guide for Policy making in an Uncertain World
Presentation of IDRC funded project, implemented by IISD (international institute for sustainable development) and TERI, studying Canadean and Indian cases.
Variability, uncertainty and change – make conventional planning scenarios less useful. Literature from different sectors was used, but little literature examples from agriculture and water sectors was found.
Policy may have unintended impacts, don't accomplish their goals. Example of a picture with the notice 'Attention: No fishing' shows that policies sometimes fail to do what they are crafted for.
In the project, researchers first talked to politicians, then to communities affected by the policies, and implementing agencies. Researchers then attributed which behavior linked to which policies. A guidebook and tools were developed, and this Toolbox will be tested in future, in new policy designs.
7 Tools from the continuum between anticipated and unanticipated conditions were presented.
1. Integrated and Forward looking Analysis
2. Multi- stakeholder deliberation
3. Automatic policy adjustments
4. Enabling self-organization and social networking
5. Decentralization of decision-making
6. Promoting variation. Different roles at different levels to be played by the policy maker were highlighted: The architect, the facilitator , the learner
7. Formal review and continuous learning (well used in India, not so much in Canada)
The linkage between the policy tasks (understand, strengthen capacity, monitor, improve), and tools and outcomes for policy.

Q (Annemarie): Thank you very much for bringing in a new perspective. Science policy interface. Have you studied how policy makers use scientific knowledge (evidence based policy making)?

A: evidence from science is taking in seriously in India. Bottleneck is uncertainty in scenarios for the future. Q: Didn't you discover short term interest (policy maker) and long term interest (scientist) conflicts? A: policy maker sees it in a longer horizon. Audience: There is a difference between a politician and a policy maker! But sometimes the policy maker themselves are the politicians.
A: I don't know how to distinguish. The time horizon does not match.

Q (Ashvin): Specific case of watershed management development. Policy development is driven by immediate goals (of local people). One component of science is missing. Trade off. How much is the implication for the overall river system. Not put into place an evaluation of that. What should we do to bridge this gap? The science is not straightforward, and the end-results may take long. But damage may be done to the system. We have systems that near closure. There has to be some science based implication there to answer these difficult questions. Tools should incorporate

Q (Catharien): Interesting presentation. One element of interest is the description of the role of the policy maker. Policy makers and their linkage for information to scientists was referred to in earlier questions (science policy interface). When considering the roles of policy makers, could you elaborate a bit how you expect the roles of scientists to change?
A: How scientist role will change, is difficult to say. We need to strengthen the science policy interface. Both the sides have to understand each other's language and each others process.

Frank Voss, University of Kassel, Germany
Future changes in water stress in India driven by socio-economic and climatic changes
Water scarcity in India – why is water scarce? Water availability and water demand aspects are highlighted: Water storage, water quality, water supply, purchase of water services. How to measure water scarcity then? 3 Water stress indicators:
1. annual withdrawals to availability ratio (w.t.a). Water stress occurs when w.t.a.>0.4 ; 2. xx; 3. per capita water availability
Tools for analyzing water scarcity trends: global integrated models (running and interpretation), global data bases, scenario analyses (probably more directions possible, funnels).
An example of a global model, the WATERGAP model, a combination of a hydrological model and a water use model was presented.
The results for a 'security first' scenario (comparable to A2 globally) were discussed for water withdrawals in India. More water in total needed (double from today in 2050). Agriculture will drop from 90 to 75% (but increasing in total). Higher climate variability will put greater demands on water infrastructure and people.
For 2050 almost all over India water stress is expected (w.t.a.>0.4). Number of people currently living under water stress 70% in rural areas, in 2050 this will most likely have changed into 65% in urban areas, while the total population number has doubled.
The results of a sensitivity analysis were shown.
Conclusion: water scarcity in India has many dimensions. Expanding supply is difficult, management of the demand side (water conservation) might help, but might not be enough. Threats of over withdrawal for ecosystems and water quality.

Research challenges are whether the right analysis are done? Are the right assumptions underlying the scenarios? What is the vulnerability of the society? Variations in this? How to balance the needs of the different sectors? How does water temperature influence water scarcity?

Q (Jeff): Electricity is there. Re-use of water?
A: water for cooling needs to be subtracted from rivers, and has to be available in the first place. And you have to distinguish between the water withdrawals and the water consumption.
Q (ECHO, EU person): how did you measure (in)efficiency in water use?
A: irrigation efficiency is different in Europe than in India, more open channels here, and improvement of efficiency is assumed. Q: also inefficiency in output per quantity of water. Has this been put in the calculation? A: No. Different systems have different efficiency.

Q (Bokshi, NL embassy): water stress or physical water scarcity? Inefficient use and inefficient management of water are important in India. Increase in water demand in agriculture (absolute) while contribution percentage of agriculture to GDP is going down. What explains the increase of water use in agriculture? I find your conclusions therefore difficult to understand and value.
A: the analysis was based on global scale data. All localities could not be taken into account. Would like to talk more about this.
Water demand is one side, the water availability is the other, and also decreases. Even when water demand is not growing much, still water stress can increase.

Q (M. Callai, Swiss embassy): you have to account for the return flow in agriculture. Water demand and water supply to be discussed, not withdrawal.
A: abstractions from river are water consumption, not withdrawals in our models.
Q: we can discuss during lunch.

Water resources: scenarios and adaptation

Chair: **David Collins**
Reporter: **Shresth Tayal**

The session started with the display of movie by WWF-India. The movie titled ‘Living With Change’ was based on the theme of the life accounts from the witness. Basically dealing with the changes being felt by the local community in the recent past in the local ecosystems and which may be attributed to the climate change. Decreasing snow, black patches, receding glaciers, increasing locust attacks were some of the most noticeable changes by the local stakeholders. Now due to increase in locust attacks, people have to buy fodders for their cattle, which was easily available from their own fields.
Many of the families have started abandoning their ancestral home and shifting to urban areas. Reduction in Indus river water is so much that the canals built by Government of India has now been abandoned. Also, the rivers which remained

frozen for significant period of the year and were used by the local community for transit, are no longer so.
In essence, the movie made a beautiful reflection of the climate change signatures already impinged on the natural systems and affecting the livelihood issues.

Ms. K. Sreelakshmi, TERI
The talk was based on the measures required to adapt to the climate change impacts. With a brief introduction about the IPCC's plan of adaptation and mitigation, a highlight was made about the various policy measures being taken and implemented by the Government of India. A light was thrown on the direct and indirect impacts possible on the water resource availability covering both the qualitative as well as quantitative aspects. The possible maladaptation possible due to wrong policy decisions or due to non-consideration of interdisciplinary sectors was also pointed out. For designing the adaptation strategy, the basic requirements highlighted were sector specific measures, evaluation of potential water resource conflicts and a careful study of trade offs. Also, a blanket strategy formulated for the entire country may not be successful, instead the requirement is to make and implement micro level strategy best suited for the local conditions.

Mr. Ashok Mishra, IITK
Climate Change – Adaptation to Agricultural Management: variability to Rainfall Occurrence and Distribution
He presented GCM projection applications to manage Maze crop input management to improve the outcome for the monetary benefits of farmers as a case study in Kenya. He concluded the observed SST based GCM outputs can help to improve the crop margins above 11% while persistence based SST feeded GCM output can help to improve the crop margin by 3.5%. At the last, he recommended to use the GCM based coarse information about the expected weather conditions in the region to improve the crop management inputs and improve the farmers future.
On being asked about the statistical approach adoption for climate change adaptation purposes, he answered that for adaptation strategy the statistical predication strategy may not help effectively. However these could be better in planner's perspective to plan for regional food security.

Ms. Annemarie Groot
With the presentation titled "Involving stakeholders in developing adaptation to Climate Change", Annemarie highlighted the need of stakeholder involvement at various stages of adaptation to climate change. She outlined the differences between 'Transdisciplinary" approach and 'Interdisciplinary Approaches" and presented the transdisciplinary approach to be better in tackling the issues of adaptation. Transdisciplinary approach deals with the cooperation between different parts of society and scientists starting from the research stage to the formulation stage and upto the implementation stage. This is a concept which aims at knowledge coproduction through interplay between science and society. Certain drawbacks of Transdisciplinary approaches were also outlined, but the advantages outweigh them.

Panel discussion

Discussion leader: **Annemarie Groot**
Reporter: **Christel Prudhomme & Nies Springer**

Mr Pradeep Kumar, Indian Forest Service
Mr Ashok Jaitly, TERI
Mr Philippe Quevauviller, EU

A. Jaitly: The film on Ladakh is misleading, not scientific enough. Some statements were very string but not necessarily backed-up with scientific evidence. It does not say that tremendous greening has occurred with agriculture, horticulture, irrigation, and entire economic and societal change: perhaps not all the changes that have occurred could be necessarily due to climate change. Regarding policy, to make outputs of HighNoon usable, there is a real need to make institutional reforms: will the project be addressing this issue. TERI could make a contribution in this area. The most important learning of such project is to be multi sectoral and multi-dimensional: very important for policy perspective. In India, do the institutions encompass this understanding? Some suggestions is that it does, but might be only at the policy level – document of good intention – but not necessarily implemented. How to identify how to make a policy effective and implemented is difficult.
Institutional reform: Fulco: the project does not aim to tackle institutional reform, Might be one of the adaptation tool that could be implemented. Unfortunately can't include everything. Perhaps towards the end we might start to see if possible to see if institutional changes are necessary. In Holland some projects do look at that very issue, and lead to different ministries to work together.
Policy implementation: Cathrien: If all uncertainties and multi-sectoral aspects of the problems are looked at , that would be good., But in practice, we will see if we can find some good solutions. High Noon will not provide solutions but opportunities to work together and try to find new approaches together

P. Quevauviller : As Ec Scientific officer 1) project and other projects have put water higher in the CC agenda ; policy orientation very linked to adaptation and water management planning. No yet adaptation policy in place : this is under development at present. High Noon will bring a new component with new cooperation, but not policy development. IPPCC is supporting policy. Question: will we have a local policy adaptation? We don't know. 2) High potential with synergies with other projects such as WATCH, COST733 etc,..: that should be pursued: we need to share data and expertise. 3) EU0India scientific cooperation. New project soon negotiated on CC impact on urban flooding with Bangladesh and China. This critical mass should be taken advantaged of, and add a very strong impact on political scene. 4) It is very hard to mixed policy and science. Needs mediators. In practice, transfer results need to be done in a 'digestible' way: effort for dissemination, reach out of communities. A lot of efforts need to be done, and this partnership s necessary, Practical recommendations and applicability of the research are needed, including feedback of policy makers. Identifying future research needs should be done together in partnership. 5) At the EC, building a front on research on CC on glacier and Monsoon, and this could have a direct input for the iPCC2011. Need to reflect at what

needs to be done in the next 2 years for being used for the IPCC: should be an aim of the project to have published papers by 2011.
Global adaptation policy? IS it possible, as adaptation is very local/regional specific (Richard Harding): Can't have a global policy. Fulco: don't need a global adaptation, but need to see at a large scale what adaptation techniques could work. To what kind of problems can we adapt? Large adaptation for large river basin can be important, e.g. Nile Ganges and other large transboundary basins. IPPC defines adaptation on natural system. Global policy makers are the participants to Copenhagen meeting. Global policy on adaptation is when adaptation and mitigation will become complementary. HighNoon can address these differentiated approaches could help. () Depends what adaptation means. Interpretation: community more robust, so be more adaptable. Can build a community specially if involved in projects for self-sufficiencies. Legal constraints would be possible. () Adaptation is complimentary to mitigation but different because local flavour: more challenging. Might not be necessary to have a policy (legal framework), but having the right mechanisms for implementation (i.e. financial). () For water, where problems are very different all over the world, it might not be possible to have a global policy.

P. Kumar : Needs to package our science so that it is understandable to policy makers so that they buy into it. Needs to make sense for them. Adaptation might be at local level: policy need to be done at local level. Modelling even at regional level might not be appropriate to be understood by states where micro management are used. The projections at national and regional level will not be very effective. The scales on why we are working are very important. The modelling must be local, for e considered for policy makers. The large scales only provide general ideas. Science without policy is blinked, policy without science it blind.
(Jan H) From a modelling perspective, local modelling is not realistic. There must be a way to have adaptation policies working at larger scales, where policies can use outputs of models at large scale.
Geographical information must be considered for policy: in India there is a very huge variety of problems, and a unique policy is not appropriate.
() Local simulation or 1-km simulations would be very costly and unlikely to be funded, so it is not likely that local CC projections are a realistic output.

Eddy Moors.
Glacier retreat – Scientific outcome. What information about glacier
Kumar: Many criteria are examined when creating a policy, including consultation. But don't have the component of future 30 years – This is now time for policy makers look at future discharge to build their policies. Glacier modelling can work so that water planning for power production are used.
Jaitly: I agree about packaging., Need to address not the level of information science to policy, as they are different levels. Packaging, and backed with ground-truth is needed. If only modelling exercise is not enough, need to be backed by ground truthing, local experience, so see what can of impact,. But it is very important.
P Q: as a policy maker, I would like to know what the impact of glaciers on the water resource on the use of water, on the ecosystem. Clear policy objectives need to be able to answer this question. An example is the WFD in Europe
D. Collins: Can't tell policy makers what they need to know, Scientific Need to respond what PM need, but PM need to have realistic questions. We need to be carefull of media impact, eg. .glaciers are disappearing as it is not true. The work

done is undermined with alarming messages m- media not very useful intermediary between science and policy.
Policies at different levels: water in India: there is this issue of policy at different levels. Discharge is a good indicator, PM need to know about data availability. If melting is starting early, glacier forming is shrinking and lengthening season lengthening, what does that mean in terms of river flow and hazard (e.g/ flood).
As a glaciologist, should contact other scientists and tell the PM what the consequences of melting in the next 5, 10 and 20 years, which are the time frame of PM
Regarding time period of melting, this is really of interest for PM: to catch when glacier will disappear.
DCollins: From a point of view of data and information, states have taken on monitoring. Normally in organised, For glaciology this is different: collected by Uni departments, and the continuity is not as good as hydrological data. In glaciology there is an urge for official gov'nt states/national/local communities. Hydro Powers etc.. might think seriously of maintaining good record of glacier measurements

Indian Monsoon : how policy can improve data availability
AJ: Accessibility of data . In India, right to information act. Otherwise a lot if data is classify. Needs policy and mind state change at policy level. Classified data must be open-up. Policy can help in defining a wider spread of institutional network for monitoring, Monsoon needs real-time data. Policy can do a lot to improve availability and also the format of data. Why not done before: because concept of classified data. Mechanism for dissemination and formatting not yet done But must be done without need to large resources
PQ: et EU, collecting data. This is huge undertaking to agree on common format. AT local level, it is a communication problem, which might be hard to achieve. Data need to be at good format and given to the people. EU can do something , but cannot be donor. Need to agree on framework but action local undertaking.
PK: A lot of data uncertainty , that need to be considered. There are many type of data, and this is a problem for PM. Need to throughout data check to insure good data quality.
Data quality is extremely important. Field data are not always reliable due to low level of education.
Monsoon data: time will come that data are released for scientific community. This is the only way science can be done.
RHarding: Need a strong statement from PM about data. Scientists can also make a joint statement supporting such a policy to push the PM to do something about data
PM: develop instrument that allow forecasting of rainfall and say what the consequences are so that PM can be convinced.
Australia is forecasting and for all stations data is available for free for the last 200 years, There is no issue in mm and for temperature. Should do have the same system for Europe. Good historical data is important to build a forecasting model
AJ: Indian data: ground data there is a lot of data of water flow, forestry, resources, Format not usable, not tested, and not accessible but a huge amount of data. PM must look at this an modernise that. It is be a huge change when done systematically, and made available to all the community. Good quality daily data

Impact Hydrological resources

AJ: Economic measures (water market/ trading/ pricing) and allocation are important for regulation. Some states have now water regulatory authorities. A number of policy measures can be taken but highly political so difficult.
PQ: Simple: Water Pricing in place in 210 linked to WFP. In principle in place to insure regulation of allocation. It is imposed at EU level.
AJ there is a political realisation about need to do something, lack of political will is due to external consumption. This is across the board, e.g. agricultural subsidies in Europe and USA. For water it is complex because water is a human right. Scientific needs to facilitate PM to make decisions. For pricing, this is not implemented because of pressure.
Solution for water prices lies outside water sector: it is political. Needs to create water storage and enhance supply. Supply-side management as well as demand-side management. In India, more and more groundwater is mined, and this is linked to political will. Adaptation will have to happen in agriculture as biggest user of water. How can this be done is a real question
Things given free have no value, and when things become scarce, need to talk to people of value of such things, Policies that distort value are unsustainable . Local level need to be considered,
How far boundaries around policies need to be defined. At what point the model might say that water availability will be so critical that will show need to new mechanisms must be implemented including GM food etc…
Fulco: Political will: because of long-term benefit and short term benefit. Water pricing must be implemented for long term but not necessary easy at short term as people don't want to pay, market water might impact badly the poorest and most vulnerable.
There is a paradox in India; the poor pay more for water more than the reach. The politicians needs to consider that and change.
Micro economics can work at local level, and education will make understand the issue of water pricing, and agree to it.

Adaptation
Kumar: Improve science packaging: best way to do it: transdisciplinary approach. All stakeholders need to be consulted to see what is most useful, and what can be delivered. This will bring the science closer to the people and PM
PQ: can't ask a scientist to think like a PM and vice versa. What is missed is an interfacing mechanism, a function recognised for people communicating between PM and scientists,. This happen in the UK at the EA, Need to develop this culture of a function at this interface. People working at the ministry or agency, In France organisation has been created. This is recognised in many countries in Europe. Consultant often play this role, but need to be recognised and rewarded. This is not a side activity it is a very important activity.,
AJ: media important channel for communication, if done rightly (and not sensationalist). E.g electronic journals etc,… This can include science publications. Need to learn from both scientists and PM : change in attitude. Must think of science-policy interface of tomorrow, e.g. at University, so that student are trained to change their attitude. It is very difficult to change behaviour – Language are different between both communities. Public money is spent in this: should not be a problem of financial burden.
Process of interfacing must be transparent so that the public knows what is going on. Need to be careful in engaging only an elite.

Fairtrade is on electronic media, on internet, and contribution is welcome for anyone. Information is collected and gathered. That could be a way to use . Let's put the information in a public domain.
The poor will be hit hardest: what policy will do to address this issue
Kumar: Needs to know where the poor are hit. Sometimes we know broadly but we don't go to them. Need to go locally to really understand the issue
PQ: In the EU the water pricing will take into account the population. Compromise between charge of water and subsidies, Water will have a price. Must be harmonised across EU, but don't know if specific action will target the poorest.
AJ: the entire process of development, unless inclusive, does not get the poor and is not effective. Decentralised governance will be more effective than any other approach to reach the poorest.

What have you learned in the seminar:
Kumar: A lot of techniques, but no perfect answer
PQ: Very interesting information about glaciology
AJ: Many things are going round, and good ideas. Question of modelling is the future regarding climate change and water. Need to strengthen it and make it wide spread and demystified