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Assessment of hydrological hazards and impact of climate change

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About the Theme

A growing body of scientific opinion predicts a continued global climate change with regional imbalances during the current century as a result of increasing concentrations of "greenhouse" gases in the atmosphere. These climate changes are likely to affect water supply, quality and demand and may have ramifications for decision makers. Increased recurrence of hydrologic hazards such as floods, droughts, soil erosion & sedimentation, etc., which are highly vulnerable to changes and variations in climate, have attracted increased attention towards these studies. This is especially more important and assumes greater significance when the demand for food and water is increasing World over. Therefore, the Theme on "Assessment of Hydrological Hazards and Impact of Climate Change" is very relevant to the present context.

There are a total of 13 papers in this Technical Session. Seven papers deal with impact of climate change on hydrology, water resources, droughts and crop production. Four papers discuss about various aspects of droughts and drought management. One paper each is devoted to flood hazards and hazards of soil erosion and land degradation.

Climate Change Impact

Siedel et. al in their paper entitled "Modeling runoff and impact of climate change in large Himalayan basin", have demonstrated the application of Snowment Runoff Model (SRM) for simulating runoff in very large river basins of Ganges and Brahmaputra and used it for examining the effect of climate change scenarios on runoff (peak and volume). In view of limited data, monthly averages of temperature and snow cover were used as daily inputs while monthly precipitation totals were empirically disaggregated to obtain daily totals. However, authors show that even then acceptable runoff simulations have been obtained. The results indicate that the already high risk of summer floods in lower reaches of Ganges and Brahmaputra may further increase under the assumed climate change scenario($T + 1.5^{\circ}$, summer precipitation increased by 10%).

In the paper entitled "Base flow analysis - a tool in assessing climate change impacts on groundwater resources", Moin et al have employed Base Flow Index (i.e., base flow relative to total stream flow) together with excess precipitation (i.e., stream flow relative to precipitation) for determining impact of climate change on ground water in the Grand River Watershed in Ontario, Canada. Impacts of climate change based on the scenarios of CCC Ma for 2090 as presented in this paper suggest that the climate change is likely to bring substantial differences in flow regimes.

Jana in his paper entitled "Vulnerability of climate and its impacts on regional drought over semi-arid zone of India", has used simple precipitation based drought index to assess impact of climate vulnerability on water and vegetation degradation of Parbhani in Maharashtra, India. The impact has been assessed using available river discharge, evapotranspiration, human population and remote sensing data. Degradation of water bodies and degeneration of vegetation have been suggested as a result of climate vulnerability.

In the paper on "Impact of climate changes on the water resources in the river Meuse basin", Roulin et. al have presented the SCHEME hydrological model by using the climate change scenarios of the IPCC. In order to extend the scale of study to large river basins in Belgium, the SCHEME model adopted IRMB model into a coarse grid version. A decrease in water resources during summer was simulated using IPCC climate change scenarios for Meuse river basin.

Two models, SLURP (Semi distributed Land Use Runoff Processes) and SWAP (Soil-Water-Atmosphere-Plant) have been used at different scales by Kite et al in their paper entitled "Climate change, water supply and crop production", to investigate the effects of a double Co_2 scenario on water availability and crop productivity within the Gediz basin in Western Turkey. SLURP modelled the hydrology of the entire basin while SWAP modelled the Cotton and Grape crops within the irrigation scheme. Double Co_2 scenarios of UKMO's GCM were used to simulate their effects and these were found to have serious impacts on water supply and crop production.

Mehrotra in his paper entitled "Hydrologic sensitivity of some Indian basins to expected climate change and its effect on water availability using disaggregated CGMS outputs", has studied the sensitivity of climate change on various hydrologic components using the disaggregated GCM outputs by employing a conceptual regional rainfall-runoff model in humid, dry sub-humid and moist sub-humid regions in Central and Southern India. Based on the best fit GCM output (precipitation), selection of GCM model was made. Author has rightly cautioned about the limitations of such a qualitative assessment in view of the limitations of GCMs. It has been also observed that basins belonging to relatively dry climatic region are more sensitive to climate change. This is in confirmation with previous studies conducted elsewhere.

Singh has examined the ability of a coupled atmosphere ocean climate model (ECHAM 3 + LSG) at T21 resolution to simulate the trends and interannual variability in an area averaged annual mean surface air temperature and summer monsoon precipitation over Indian subcontinent in his paper on "Effect of anthropogenic radiative forcings in the

simulation of long term trend and variability in Monsoon Climate". Three experiments the Control, the GHG and the GHG + Aerosol were adopted in this study. The results suggest that simulation inGHG + Aerosol forcing experiment was superior in portraying the trend in area averaged annual mean temperature over Indian sub-continent while the model was unable to simulate the observed trend in monsoon rainfall.

Hydrologic Hazards - Drought

Panu and Sharma have presented a comprehensive review and state of the art on drought research in their paper entitled "Challenges in drought research : Some perspectives and future directions". Drought variables, drought parameters, severity indicators, methods and tools for drought analysis and state of the art drought forecasting techniques have been examined and reviewed. A number of suggestions have been made for future research including drought analysis on short time basis, drought severity aspects, forecasting the onset and termination of droughts, regional drought frequency analysis, handling of drought as a risk based approach rather than crisis based approach and dissemination of drought research results for practical usage.

A comparative study of technological interventions like water harvesting through on farm reservoirs (OFR) and dry seeded rice (DSR), for drought alleviation in the rainfed low land rice systems of northwest Bangladesh is presented by Saleh in his paper entitled "A study on farmer's crop management practices and opportunities for drought alleviation in rainfed low land rice systems". Based on the results of field experiments and farmer's survey, author questions the applicability of water harvesting through OFR owing to its physical limitation in flat low lands and farmers choice because of tenantship and small and fragmented holdings. It suggests that the DSR technology requires less water and has the potential for alleviating drought in the rainfed low land rice systems in the study area.

In the paper entitled "Drought recurrence in different climatic regions in India", Pandey and Ramasastri, have used the ratio of mean annual precipitation (Pa) to global terrestrial mean annual precipitation (Pg), and ratio of mean annual potential evapotranspiration (Ep) to mean annual precipitation (Pa) (Ponce et. al, 2000), to define climatic regions with an attempt to develop relationship between average drought frequency and evapotranspiration / precipitation ratio in arid, semi-arid and sub-humid climatic regions in India. The average drought frequency was found to decrease from dry to wet regions. A significant relationship between the frequency of drought and Ep/Pa and (Ep- Pa)/Pa has been reported and it is suggested that this may serve as a tool for the prediction of regional drought frequency.

Pandey et. al. in their paper entitled "Drought investigations and crop water need in Kalahandi District in Orissa", have analysed 31 years of rainfall data to study the magnitude and frequency of drought in terms of rainfall departure, probability distribution of rainfall, onset and withdrawal of effective monsoon and critical dry spell analysis using the standard available techniques. Estimation of crop evapotranspiration for Kharif (monsoon) season and irrigation requirement for the critical dry spells have been also presented to plan supplemental irrigation. Recurrence of moderate to severe drought with average frequency of once in 4 to 8 years could be found. The study also suggests adoption of short duration paddy varieties in the study area.

Flood, Cyclones and Soil erosion / land degradation

In the paper entitled "Forecasting and warning of water related disasters in a complex hydraulic setting - The case of Bangladesh", Paudyal has presented a general overview of models developed and applied to study and predict floods and cyclones in Bangladesh. The modelling system includes the MIKE 11 model and the Flood Watch System for flood forecasting. The two dimensional hydro-dynamic model based on the MIKE 21 System is employed to simulate storm surges during cyclones.

De-Silva has presented problems and some mitigation measures of soil erosion and land degradation including landslides as the major hydrological hazards in Sri Lanka in his paper entitled "Assessment and mitigation of hydrologic hazards in Sri Lanka". Soil loss under major crops e.g., tea, rubber, tobacco, chenna cultivation under different management practices has been reviewed and presented along with rate of sedimentation in reservoirs. Some soil management aspects and time tested Sloping Agricultural Land Technique (SALT) for erosion control have been covered. Education and awareness are suggested to minimise impact of these hazards.

Major Recommendations

To make more realistic estimates of impacts on hydrology at basin/regional scale, there is a strong need for improvement of climate models and development of regional scale climate models with improved hydrologic parameterization so as to obtain more meaningful data on regional scale for impact studies.

Hydrologic and crop models (Soil--Water--Crop) may be coupled to investigate the effects of climate change on water availability and crop production.

There is a need to develop suitable methods and techniques for forecasting the onset and termination of droughts and to have regional drought frequency analysis to help plan measures for mitigating impacts of drought.

It may be worth studying the severity and vulnerability of hydrologic hazards under the influence of projected climate change and to suggest preparedness strategies to mitigate their impacts.