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Research Paper

Uncertainty of Streamflow Forecasting with the Climate Change Scenario in India

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ABSTRACT

Streamflow and rainfall estimates have utmost importance to compute detailed water availability and hydrology for many sectors such as agriculture, water management, and food security. There are various models developed over the years for runoff estimation but among them only a few models incorporate climate change factors. Snowmelt and rainfall are the main sources of surface as well as groundwater resource and the main inputs in runoff models for estimation of streamflow. There are numerous factors which leads to climate change which intern affects the distribution on rainfall on spatial and temporal scales and the rate of melting of snows in the Himalayan region.
Uncertainties in projected changes in the hydrological systems arise from internal variability in the climatic system, uncertainty about future greenhouse gas and aerosol emissions, the translations of these emissions into climate change by global climate models, and hydrological model uncertainty. Projections become less consistent between models as the spatial scale decreases. The uncertainty of climate model projections for freshwater assessments is often taken into account by using multi-model ensembles. The multi-model ensemble approach is, however, not a guarantee of reducing uncertainty in mathematical models.

In recent years the floods have occurred due to high intensity rainfall occurred in a very short time, but in several cases the flooding has also occurred because the rainfall has fallen at times when all the storage systems have not been emptied after the previous rainfall. This is what we call coupled rainfall. There is currently no recommendation for how to take coupled rainfall account when applying the climate change scenario. It is estimated that such changes represent at a large scale, and cannot be applied to shorter temporal and smaller spatial scales. In areas where rainfall and runoff are very low (e.g., desert areas), small changes in runoff can lead to large percentage changes. In some regions, the sign of projected changes in runoff differs from recently observed trends. Moreover, in some areas with projected increases in runoff, different seasonal effects are expected, such as increased wet season runoff and decreased dry season runoff. Studies using results from fewer climate models can be considerably different from the other models.

Key words – Climate change impacts, Streamflow estimation, Coupled rainfall.

INTRODUCTION

In the wake of changing climate, the present water crisis seems to tighten its hold on the mankind hence water resources estimation is integral part of planning, development and management of water resources (Lal, 2001; Barnett et al., 2001) of the country and the estimation of water resource is based on several hydrological and meteorological parameters. Climate change is the change in the long-term weather pattern over a region such as

change in rainfall patterns, evaporation, due to emission of greenhouse gases leading to ozone layer depletion, global warming and melting of glaciers. Scientists and researchers have noticed changes in evaporation patterns which has drastically worsened in the last 50 years.

"We are close to a tipping point where global warming becomes irreversible" – Stephen Hawking. Hawking very recently corrected his own prediction of last year that we only have 100 years to live before doomsday instead of 1000. It was first highlighted globally at the UN Conference on Development and Environment (UNCED) in Stockholm, 1972. Svante Arrhenius in 1896 found a relation between the rise in global temperature and CO2 by doubling the concentration of atmospheric carbon dioxide he found that it would increase 5^0 Centigrade in 750 years i.e. by 2646.

Since it's all happening at a larger scale where the earth as one is in a need for a change in order to reduce the impacts of climate change as it has been observed that climate change is anthropogenic (Nair, 2016; Barnett et al., 2001; Huber and Knutti, 2011). There are various evidences or indicators of climate change such as global temperature rise, warming oceans, shrinking ice sheets, glacial retreat, sea level rise, extreme events such as floods and droughts, ocean acidification (Arrhenius, 1896; Barnett et al., 2001; Huber and Knutti, 2011; Gibelin and Deque, 2002; Rosenzweig et al., 2008) and many more.

The impacts of growing population, increase in emission of greenhouse gases, increase in pollution far above safety limits from untreated domestic, industrial and agricultural effluents (Brenkert & Malone, 2005; Nair, 2016; Oreskes, 2004; Gibelin & Deque, 2002; Barnett, Pierce, & Schnur, 2001; Huber and Knutti, 2011) all of which has contributed directly or indirectly towards the rapid climate change.

CLIMATE OF INDIA

It comprises a wide range of weather conditions across a vast geographic scale and varied topography, many regions have starkly different microclimates. In general India has 4 Seasons namely Winter (December, January and February), Summer (March, April and May), Monsoon or Rainy season (June to September), Post-monsoon period (October to November). The tropic of cancer passes through the middle of India, the bulk of the country can be regarded as climatically tropical. As in much of the tropics, monsoonal and other weather patterns in India can be wildly unstable: epochal droughts, floods, cyclones, and other natural disasters are sporadic, but have displaced or ended millions of human lives. There is one scientific opinion which states that in South Asia such climatic events are likely to change in unpredictability, frequency, and severity. Ongoing and future vegetative changes and current sea level rises and the attendant inundation of India's low-lying coastal areas are other impacts, current or predicted, that are attributable to global warming (Ravindranath et al., 2011).

IMPACTS OF CLIMATE CHANGE IN INDIA

India's large and growing population is leading to increase in pollutants in the atmosphere so as the emissions of greenhouse gases due to which the potential impacts of climate change in India are severe: which include sea level rise, changes in monsoon patterns, severe storms and flooding, unexpected droughts, changes in temperature all of which leading to altering the hydrology of the catchments (Nune et al., 2013; Brenkert and Malone, 2005). Climate

variability in the form of floods and cyclones has resulted in destruction of crops, property, infrastructure and human lives. The costs of a 1-m rise in sea level could include up to 7 million people displaced from India's coastal regions says Brenkert and Malone (2005) in a study of modelling vulnerability and resilience to climate change in India. O'Brien et al. (2004) have mapped vulnerability to multiple sectors due to climate change and globalization in India taking agriculture as an example to show climate change impacts. Area-averaged annual mean surface temperature is expected to rise between 3.5 to 5.5˚C by 2080 says Lal (2001). According to Global Climate Risk Index, 2018 India is in the top 10 vulnerable nations to climate change.

STATUS OF WATER RESOURCE ESTIMATIONS

Already due to the complex nature of our hydrological cycle, estimations of streamflow have its limitation with increasing unpredictability in the rainfall patterns and other climatological factors accuracy of streamflow estimates will also get affected. Bhatt and Mall (2015) state that during recent years, the Global Climate Models (GCMs) and Regional Climate Models (RCMs) driven hydrological models are in frequent use but have been found to lack reliability. Lal (2001) in climate change: implications for India's water mentions that warmer climate will enhance hydrological cycle i.e. higher evaporation, greater proportion of liquid precipitation which will affect soil moisture, groundwater reserves and the frequency of floods and droughts. In the wake of changing climate the present water crisis seems to tighten its hold on the mankind hence water resources estimation is integral part of planning, development and management of water resources of the country and the estimation of water resource is based on several hydrological and meteorological parameters. During recent years, the Global Climate Models (GCMs) and Regional Climate Models (RCMs) driven hydrological models are in frequent use but have been found to lack reliability (Bhatt and Mall, 2015).

CURRENT POLICY, FRAMEWORK AND PRACTICES

Under National Action Plan on Climate Change (NAPCC) India has 8 national missions; solar mission, mission for enhanced energy efficiency, water mission, mission on sustainable habitat, mission for sustaining the himalayan ecosystem, mission for green india, mission for sustainable agriculture, and mission on strategic knowledge for climate change. India being the 3rd amongst the greenhouse gas producing countries need immediate measures and strategies to fight the devastative impacts of climate change which are mostly due to anthropogenic factors. India is now expected to obtain 40% of its electricity from non-fossil fuel or low carbon sources by 2022 which 8 years ahead of schedule says New York Times. India's government has now forecast that no new coal-fired power stations will need to be built for at least 10 years and recently because of increased air pollution in New Delhi, festival fireworks during Diwali 2017 were banned in order to reduce air pollution. Sale of new petrol or diesel cars would be banned from 2030. According to Prime Minister of India , Narendra Modi in one of his speeches says “We will mass produce it, mass aggregate it, mass process it for the world, America did it for the first billion people. India is now doing it for the rest of the six billion on the planet” which is directly connected to Make in India campaign as well as production of energy efficient appliances will reduce not only India's contribution to climate change but globally. India and other developing countries have stepped up the pressure for a formal discussion on the efforts countries are taking to slow down global warming in the “pre-2020” period (Paris Agreement, 2016). Table 1 summarizes the issues and the proposed redial measures.

Table 1. Evaluation of the adequacy for climate change impact identification, purposes, mitigation or adaptation measures

Impacts	Spatial Coverage	Data Collection/ Availability	Modelling	Case Studies / Present Status	Impact Evaluation	Reviewed Publication	Adaptation and Mitigation
High Intensity Rainfall, Monsoon Pattern	All scenarios have different targeted sectors such as A2 focuses on emission on greenhouse while A1 has emphasis on technological changes.	Available	SRES 'Marker' emission scenarios (A1, A2, B1 and B2), A–O GCM of the CCSR/NIES, ECHAM1, T21, LSG, ECHAM3, RCM, GCM, WRF-ARW, WRF, HadRM2	Many	Many studies have been done and are still undergoing for in-depth knowledge about climate change impacts	(Bhatt and Mall, 2015; Lal et al.,1994) Effect of global warming on Indian monsoon simulated with a coupled ocean-atmosphere general circulation model, (Lal et al., 1995; Kolusu et al., 2014)	Water Harvesting Measures, Flood routing
Droughts	Drought risk areas	Moderately Available		Few		(Lal, 2001; Lal et al., 1994)	
Emission of greenhouse gases		Available	SRES 'Marker' emission scenarios (A1, A2, B1 and B2),	Many		(Bhatt and Mall, 2015; Nair, 2016; Gibelin and Deque, 2002; Brenkert and Malone, 2005; Arrhenius, 1896; Lal, 2001)	Controlled use of greenhouse emitting appliances such as air conditioners, CFC's have been replaced by other non-harmful gases in refrigerators, no new coal-fired power plants are constructing for the next 10 years
Severe storms and flooding		Available				(Kitoh et al., 1997, Lal et al., 2000)	Construction of resilient infrastructure, Improvement in awareness and warning measures
Rise in Sea Level	All coastal regions	Available				(Brenkert et al., 2005)	
Rise in Temperature	Country Wide	Available		Some		(Lal, 2001; Lal et al., 1995; Lal et al., 2000)	

PRIORITY OF ON-GOING ACTIONS

- Strategic knowledge on climate change to identify the challenges and the responses to climate change
- Solar Mission to reduce the use of non-renewable energy sources
- Water Mission to conserve water, minimize wastage and ensure more equitable distribution both across and within states.
- Enhanced Energy Efficiency by accelerating the shift to energy efficient appliances, developing fiscal instruments
- Sustainable Agriculture to progressively adapt to the projected climate change and practice the recommended measures accordingly for food security
- Capacity Building (Prevention, Mitigation and Preparedness)
- Response (Immediate Relief, Rehabilitation and Reconstruction)

CONCLUSIONS

- It is recommended to put up more effort and research on droughts due to climate change because of limited published research work available in Indian context and droughts cover maximum risk areas.
- Strategic knowledge about climate change identify the challenges and responses such as capacity building for the same in various sectors such as agriculture, water resources etc would be a way forward towards tackling climate change in various scenarios.

REFERENCES

Arrhenius, S. 1896. On the influence of Carbonic Acid in the air upon the temperature of the ground. Philosophical Magazine and Journal of Science, 41:237-276.

Barnett, T. P., Pierce, D. W. and Schnur, R. 2001. Detection of Anthropogenic Climate Change in the World's Oceans. Science, 292: 270-274.

Bhatt, D. and Mall, R. 2015. Surface Water Resources, Climate Change and Simulation Modelling. Aquatic Procedia 4 (pp. 730-738), Varanasi, India: International Conference on Water Resources, Coastal and Ocean Engineering (ICWRCOE 2015).

Brenkert, A. and Malone, E. 2005. Modeling Vulnerability and Resilience to Climate Change: A Case Study of Indian and Indian States. Climate Change, 57:102.

Chen, X., Pauluis, O. M. and Zhang, F. 2017. Regional Simulation of Indian summer monsoon intraseasonal oscillations at gray zone resolution. Atmospheric Chemistry and Physics, 1:45.

Gibelin, A. L. and Deque, M. 2002. Anthropogenic climate change over the Mediterranean region simulated by a global variable resolution model. Springer-Verlag, 327-339.

Huber, M. and Knutti, R. 2011. Anthropogenic and natural warming inferred from changes in Earth's energy balance. Nature Geoscience, 31-35.

Kolusu, S. R., Prasanna, V. and Preethi, B. 2014. Simulation of Indian Summer monsoon intra-seasonal oscillations using WRF regional atmospheric model. International Journal of Earth and Atmospheric Science, 1:35-53.

Kumar, K., Sahai, A., Kumar, K., Patwardham, S., Mishra, P., Revadekar, J. ……and Pant, G. (2006). High-resolution climate change scenarios for India for the 21st century. Pune, India: Current Science, 90.

Lal, M. 2001. Climatic Change Implications for Indias Water. Journal of Social and Economic Development, 57-87.

Lal, M., Cubasch, U. and Santer, B. D. 1994. Effect of global warming on Indian monsoon simulated with a coupled ocean-atmosphere general circulation model. Current Science, 66: 430-438.

Lal, M., Cubasch, U., Voss, R. and Waszkewitz, J. 1995. Effect of transient increase in greenhouse gases and sulphate aerosols on monsoon climate. Current Science, 69:752-763.

Meenu, R., Rehana, S. and Mujumdar, P. 2012. Assessment of hydrologic impacts of climate change in Tunga-Bhadra river-basin, India with HEC-HMS and SDSM. Bangalore, India: Hydrological Processses, 18.

Mondal, A. and Mujumdar, P. 2015. Regional hydrological impacts of climate change: implications for water management in India. Hydrological Sciences and Water Security: Past, Present and Future (pp. 34-43).

Paris, France: International Association of Hydrological Sciences, 366.Nair, K. 2016. Impact of Climate Change and Anthropogenic pressure on the water resources of India: Challenges in management. Kerala, India: International Association of Hydrological Sciences.

Nune, R., George, B., Malano, H., Nawarathna, B., Davidson, B. and Ryu, D. 2013. An Assessment of Climate Change Impacts on Streamflows in the Musi Catchment, India. Melbourne: Department of Infrastructure, The University of Melbourne.Oreskes, N. 2004. The Scientific Consensus on Climate Change. Science, 306.

Ravindranath, N. H., Bala, G., and Sharma, S. K. 2011. In this issue. Current Science, 101 (3): 255-256.

Rosenzweig, C., Karoly, D., Vicarelli, M., Neofotis, P., Wu, Q., Casassa, G., . . . Imeson, A. 2008. Attributing physical and biological impacts to antropogenic climate change. Nature, 453: 353-357.

https://www.nytimes.com/2017/05/22/opinion/paris-agreement-climate-china-india.html