DIVECHA CENTRE FOR CLIMATE CHANGE

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Sustainable Water Future Programme

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

Towards a Sustainable Water Future

A Future Earth Conference

24 - 27 September 2019

Conference Proceedings


Towards a Sustainable Water Future





Towards a Sustainable


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SUSTAINING THE HIMALAYAN
ECOSYSTEM

IWA
the international
water association

6th IWW
2019

IV. Programme Schedule

Tuesday, 24 September

09:30	**Inaugural Ceremony at the Indian Institute of Science (IISc)** 09:30 – 11:30 Venue: Indian Institute of Science, JN Tata Auditorium
13:30	**Advanced Water System Assessment to Address Water Security Challenges of the 21st Century (Plenary)** 13:30 – 15:30 Venue: Hotel Sheraton, Grand Ball Room
16:00	**Aerosols, Clouds, Precipitation and Hydrological Cycle (Special Session)** 16:00 – 19:30 Venue: Hotel Sheraton, Jupiter *Organized by Divecha Centre for Climate Change and Space Physics Laboratory*
	Assessing Sustainability in Water Space 16:00 – 17:30 Venue: Hotel Sheraton, Grand Ball Room 2
	Future of Urban Waterbody Rejuvenation (Special Session) 16:00 – 19:30 Venue: Hotel Sheraton, Grand Ball Room 1 *Organized by Consortium of DEWATS Dissemination Society (CDD)*
	Groundwater Assessment and Analytics 16:00 – 17:30 Venue: Hotel Sheraton, Neptune
	Water-Energy-Food Nexus Assessment and Governance 16:00 – 17:30 Venue: Hotel Sheraton, WTC Building, Seminar Hall 1
	Water Solutions for the 21st century in the Indian Himalayan Region and Climate Impacts on Global Mountain Water Security (Special Session) 16:00 – 19:30 Venue: Hotel Sheraton, Ceres *Organized by Integrated Mountain Initiative (IMI) and Global Water Futures (GWF)*

Wednesday, 25 September

09:00	**Cryosphere and Water Security (Special Session)** 09:00 – 18:00 Organized by Divecha Centre for Climate Change
	Water and Climate Change: Challenges (Plenary) 09:00 – 11:00
11:30	**Aerosols, Clouds, Precipitation and Hydrological Cycle (Special Session)** 11:30 – 18:30 *Organized by Divecha Centre for Climate Change and Space Physics Laboratory*
	Geogenic Pollutants in Groundwater 11:30 – 13:00
	Groundwater Quality and Assessment I 11:30 – 13:00
	Innovations to Achieve Sustainable Groundwater Use in India (Special Session) 11:30 – 13:00 *Organized by Groundwater Solutions Initiative for Policy and Practice, International Water Management Institute and International Association of Hydrogeologists*
	Lake Quality Assessment and Case Studies 11:30 – 13:00 Venue: Hotel Sheraton, Grand Ball Room 2
	Leaving No One Behind: Digital Water, Big Data, Technology and Water Security 11:30 – 13:00
	Water Assessment in River Basins: Perspectives 11:30 – 13:00
	Water and Climate Change Assessment I 11:30 – 13:00
	Water and Climate Change Assessment II 11:30 – 13:00
14:00	**Role of Big Data, AI, Blockchain Technology in Water Diagnostics and Governance (Plenary)** 14:00 – 16:00
16:30	**An Exploration of Capacity Building: Needs and Priorities for Advancing Water Security in the Global South (Special Session)** 16:30 – 18:00
	Data Issues and Needs Related to Monitoring Sustainability in Water Space 16:30 – 18:00

	Freshwater Conservation and Development Planning: Novel Integrative Approaches and Big Data 16:30 – 18:00
	Groundwater and Climate Change Adaptation 16:30 – 18:00
	Innovatively Addressing Water, Energy, and Food Security Challenges (Special Session) 16:30 – 18:00 *Organized by Texas A&M University*
	Resilience in Urban Water Systems: Methods 16:30 – 18:00
	Sustaining Water Resources (Special Session) 16:30 – 18:00 *Organised by the Indian Institute of Science (ICWaR) and the Centre for Ecology & Hydrology, UK*
	Urban Flood Risk and Adaptation 16:30 – 18:00
	Water and Climate Change Assessment: Himalayas 16:30 – 18:00
18:00	**Poster Session** 18:00 – 19:30

Thursday, 26 September

09:00	**Global Water Governance: Challenges (Plenary)** 09:00 – 11:00
11:30	**Ambient Water Quality for Development (Special Session)** 11:30 – 13:00 *Organized by United Nations Environment Programme and Environmental Research Institute, UFZ, Germany*
	Governance: Knowledge Management and Innovation 11:30 – 13:00
	Water-Energy-Food Nexus Governance 11:30 – 13:00
	Water-Energy-Food Nexus under Drought: Assessment and Quantification (Special Session) 11:30 – 13:00 *Organized by Centres for Natural Resources and Development and Institute for Technology and Resources Management, TH Köln, Cologne, Germany*
	Water Issues, Assessing and Meeting Sustainable Development Goal 6 11:30 – 13:00

	Water Museum: Concepts and Collaborations (Special Session) 11:30 – 13:00
14:00	**India Water Security: Key Issues (Plenary)** 14:00 – 16:00
16:30	**Agriculture and Water** 16:30 – 19:00
	Analysis of Groundwater Contamination 16:30 – 18:00
	Case Studies of Water-Energy-Food Nexus Solutions and Implementations 16:30 – 18:00
	Groundwater Quality and Assessment II 16:30 – 18:00
	Managing Lake Water Quality (Special Session) 16:30 – 18:00 *Organized by the Ashoka Trust for Research in Ecology and the Environment, Bengaluru*
	River Basin Governance 16:30 – 18:00
	Role of Science Diplomacy in Addressing Global Water Challenges (Special Session) 16:30 - 19:30 *Organized by Department of Science and Technology Centre for Policy Research*
	Understanding Water Security Paradigms (Special Session) 16:30 – 18:00 *Organized by The Ecological Foundation and Indian Institute of Science*
	Water Security in Agriculture and Adaptation to Climate Change 16:30 – 19:00
	Water Security, Informal Water Use and Water Access 16:30 – 18:00
18:00	**Poster Session** 18:00 – 19:30

Friday, 27 September

09:00	**An Integrated Global Vision for Water Security: Approaches and Methods** 09:00 – 10:30
	Climate Change and Water Management (Special Session) 09:00 – 10:30 *Organized by TERI School of Advanced Studies*

	Ecohydrology: Engineering Harmony for a Sustainable World (Special Session) 09:00 – 10:30 *Organized by Indian National Committee for International Hydrological Programme, National Institute of Hydrology, Roorkee*
	Groundwater Governance 09:00 – 10:30
	Impacts of Climate Change on Water 09:00 – 10:30
	Interlinkages in Urban Water Systems 09:00 – 10:30
	Rethinking Urban Water Supply Management (Special Session) 09:00 – 10:30 *Organized by Council on Energy, Environment and Water*
	Solutions in Water Quality Management 09:00 – 10:30
	Water Ethics: Concepts and Approaches 09:00 – 10:30
	Water Quality Assessment: Case Studies 09:00 – 10:30
11:00	**Groundwater Assessment and Agriculture** 11:00 – 12:30
	Solutions to Promote Sustainability in Water Space 11:00 – 12:30
	Technology-based Solutions in Addressing Water Quality 11:00 – 12:30
	Digital Technology for Sustainable Water Management 11:00 - 12:30
	Urban Flood Risk 11:00 – 12:30
	Urban Water Resilience and Innovation 11:00 – 12:30
	Water Challenges in the MENA Region (Special Session) 11:00 – 12:30 *Organized by Future Earth MENA Regional Center, The Cyprus Institute*
	Water Ethics: Practical Applications 11:00 – 12:30
	Water Quantity and Quality Considerations in River Basin Planning and Management 11:00 – 12:30
13:30	**Closing Plenary** 13:30 – 15:00

V. Water Future Conference: Summary

Science and policy together have played an outstanding role in addressing and understanding many systemic water risks for decades but is still unable to trace the combined effect of multiple interactions, feedbacks, and fluxes operating in spaces from planetary to local levels. We need new capabilities today to understand the integrated effects of hydrological, biological, biogeochemical economics, human health and human social behaviour at different scales in near real time which will enable us to analyse, automate, correct, predict and minimise water risks. The combined digital science and technology can provide an opportunity to address many of the water governance challenges facing water scarcity, and add value to the water as a scarce resource through increasing in distribution and operation efficiency, water and energy, reduce wastage, extend the life of existing assets, and increase access to better information for better governance. Today, digital science and technology have been inseparably connected along their path of development, and their innovative combination may provide such new capabilities in water science application to understand the effect of multiple rates of changes from global to local level, tipping points of water crisis, and pinpoint opportunities (investment, allocation) with respect to time and space and shape our sustainable water future. This will allow to address many of the water governance challenges, and add value to the water as a scarce resource through increasing in distribution and operation efficiency water and energy, reduce wastage, extend the life of existing assets, and increase to access to

Fig 1: The Global Water Future Conference 'Towards a Sustainable Water Future' .

better information for better governance, and towards higher impact on human wellbeing.

Towards this endeavour, an international conference titled 'Towards a Sustainable Water Future' was organized by Divecha Centre for Climate Change, Indian Institute of Science and Sustainable Water Future Programme in Bengaluru, India from 24 to 27 September 2019. The conference addressed the current state of global water resource challenges, future pathways and scenarios, and different technological, institutional solutions to accelerate the implementation of water-related SDGs and the 2030 Agenda targets with an aim of 'leaving no one behind'. Around 700 participants all across the globe attended the conference thus giving a major opportunity for academics, water practitioners, policymakers,

Conference Strength
700 Participants
5 Plenaries
10 Themes
6 Cross Cutting Themes
45 Parallel Sessions
20 Special Sessions

scientists, civil society and government officials to discuss the direction that the global science community should take in order to solve myriad of challenges affecting our water systems in real time, and develop new frontiers for innovative solutions. The major highlight of the Water Future Conference include signing of MOU between the Water Solutions Lab, Bengaluru (a joint initiative of Divecha Centre for Climate Change and Sustainable Water Futures Programme) and the Bengaluru Water Supply and Sewerage Board (BWSSB) with the aim to establish a collaborative partnership, founded on the principles of collaboration and cooperation, to provide expertise and resources for undertaking coordinated and strategic research activities that will underpin the sustainable management and use of water in this time of significant global environmental change. The broad aim is to enhance the contribution of strategic scientific and technical research and innovation to the sustainable management for the city of Bengaluru. Other highlights include, setting up a platform for the launch of the Mountain Solutions lab in 2020 with an aim to understand, analyze and address the impacts of climate change on water availability and security for the Indian Himalayan Region.

The outcome of conference titled Bengaluru - Budapest Science Action Plan was an input to a high-level political event called the Budapest Water Summit organized by the Government of Hungary from 15-17 October. The Bengaluru – Budapest Science Action Plan calls for the development of an evidence-informed and value-based digital operating framework for water across scales that will integrate various aspects such as hydrology, biogeochemistry, ecology, human health, culture, social-economic behaviour, and institutions along with understanding feedbacks at different scales in near real-time for all stakeholders with an aim to identify, predict and adjust responsible production and consumption behaviours under varying risk conditions based on evidence-based science.

Fig 2: Budapest Water Summit organized by the Government of Hungary from 15-17 October.

VI. Outcomes

Fig 3: The Global Water Future Conference held at the J.N. Tata Auditorium on 24 Sep 2019.

1. The Bengaluru – Budapest Science Action Plan towards Sustainable Water Futures 27 September 2019

Context:

Humankind is in the midst of an unprecedented global water crisis. Problems related to water scarcity, water pollution, loss of ecosystem integrity, land degradation, failure of essential water infrastructure and extreme climatic events like floods and droughts are occurring at hitherto unseen rates and scales all over the world. The impact is particularly magnified across the Global South, affecting its economy, human health, biodiversity, natural environment and society at large. Many cities face tipping points despite considerable efforts to provide water security. Many regions are facing severe droughts and crop failures – both of which are set to increase in frequency and intensity. We have seen extreme events never observed, with significant loss of life. Millions of people are condemned to leave their homes each year in search of water and alternative livelihoods. The water crisis is inextricably linked to human health, food, and energy. It has the capacity to significantly disrupt the sustainability of the economy, environment and society. In spite of all the enormous mobilization of the world's governments, civil society and business communities, we are already off track in implementing SDG 6 and the other water-related SDG targets. The 2030 Agenda for Sustainable Development will likely not be met by 2030, resulting in large scale environmental and societal impact as we move into mid-century.

Issues:

The risks born out of the interaction between natural processes -- hydrological, biogeochemical, and ecological — and anthropogenic systems (such as engineered systems, law, governance, institutional practices, cultural systems and human behaviour) remain difficult to understand, analyse, couple and predict. These complex interactions result in many unknowns that are rapidly evolving. For decades, science and technology, including the social sciences as well as engineering, have played a central role in identifying and understanding systemic water risks. The accelerating pace of changes in water systems and how they interact with other sectors are creating new risks to society. These are difficult to capture with existing observation and analytic infrastructure. More recently, satellite imaging, modelling, artificial intelligence, data integration and assimilation have transformed our view of the water system from a local issue to a global one. However, the advancements made in science and technology have been outpaced by the growth of the complexity in water systems. The accelerating pace of changes in the water system and water delivery services and how they interact with other sectors are creating new risks to society that are difficult to capture with existing observation and analytic infrastructure. This leads to vast information gaps, which in turn, result in poor decision-making.

As a consequence, the global community will continue to struggle to meet its energy, food and water demands, propelling us towards a stage that cannot be reversed and can lead to political crises. Business-as- usual is no option. We need to develop new innovative real-time solutions.

Towards an evidence informed and value based digital operating framework:

Science and technology must make a leap in understanding—and then responding to—the constantly changing water system and close this information gap. To ensure sustainable water futures require partnerships across academia, governments, UN and other intergovernmental, development organizations, civil society and the business sector. The realities described above motivate the international water science and management community assembled in Bengaluru, India, to call for a set of actions given the sustainable development imperatives associated with water and other connected development goals.

We urge a strategic partnership of scientists, public stakeholders, decision-makers, political leaders and the private sector to develop a broad multi-perspective action plan. **Specifically, the conference calls for the development of an evidence informed and value based digital operating framework for water across scales that will integrate effects of hydrological, biogeochemical, ecological, human health, cultural, social-economic behaviour, institutions and will help understand feedbacks in near real-time for all stakeholders.** This will enable us to identify, predict and adjust responsible production and consumption behaviours under varying risk conditions based on evidence-based science.

The Action Plan:

This operating framework must leverage advanced cyber-infrastructure and integrate multiple subsystems in the domain of, but not limited to, hydrological, biogeochemical, and ecological and anthropogenic processes. It can be developed by embedding existing scientific models with big data analytics, cloud computing, augmented intelligence, deep-learning techniques and distributed ledger systems like blockchain technologies to verify information flows. The system can be powered by the growing arsenal of free, publicly available digital information streams and in near real-time enable us to operationalize predictive science and technological inventions for water-related decision-making across numerous scales.

Such a new digital operating framework is essential to help society understand the potential tipping points of the water crisis in order to mitigate the impact. This framework would allow us to pinpoint opportunities, such as investment, allocation, and engineered interventions, with respect to time and space and shape our strategic thinking on sustainable water futures. This framework will be connected and will feed existing platforms for improved performance. It also will allow the water community to address many of the current and expected water governance challenges, and help manage critical water resources by increasing the knowledge distribution on improving operational efficiency, reducing waste, extending the life of existing assets, and protecting the very aquatic biodiversity and ecosystem services upon which reliable water systems depend.

What we propose here is a paradigm shift. We propose a new innovative approach on how information is to be collected, processed, and used in decision making at different scales. The framework should be value-based and incorporate safeguards against the ever-evolving challenges related to data privacy, cybersecurity and ethics. Such a paradigm shift is to improve human and environmental health and well-being, increase innovation opportunities, create jobs and ultimately have a positive societal impact.

The Bengaluru Water Future Conference submits the following recommendations for general consideration, with a view to the proceedings of the Budapest Water Summit 2019 in particular:

Creating a digital environment

- Through appropriate capacity development activities facilitate the work of an interdisciplinary team of scientists, humanists, policy specialists and digital technologists to develop the architecture for the integrated digital water management framework across scales.
- Develop partnerships with non-water actors who pioneered integrating disruptive technologies and adopt appropriate good practices.
- Enable the fast and effective transfer of modern data science, modelling and other relevant new water management tools for the benefit of developing countries, particularly in Africa and South and Southeast Asia.
- Facilitate the inclusion of citizen scientists to amplify data capture and provide

verification of these important new information streams.

- Capitalize on the most recent advances in space technology for the benefit of sustainable water resources management, seamlessly enabling up and downscaling.

Creating an integrated architecture

- Use new design tools based on deep learning, advanced neural networks, artificial intelligence, machine learning to map out static (e.g., engineered infrastructure) and time-varying (e.g., watershed state and natural capital) elements of and linked to water systems and develop meaningful and traceable indicators for policy planning.
- Implement greater access, openness and transparency in data heritage and governance.
- Design ethics-based cyber information systems which take into account the notion of equity, fairness, social justice, conflict avoidance and water-sharing support system
- Integrate into this framework the current water resources assessment capabilities. Refine modelling of coupled social and environmental processes, including detection of potential water-related in-country and transboundary conflicts and migration.
- Develop machine learning tools that appropriately consider the accelerating hydrological cycle under climate change and invokes non-stationarity for an improved estimation of relevant design values. The impacts of non-stationarity will result in higher occurrence probabilities of extremes, such as floods and droughts, for which the research, technology and policy community will need to develop adequate responses, including social ones.

Developing capacity to deliver digital transformation in the water sector

- Gender-sensitive capacity building approaches targeting emerging digital technologies should initiate, from the outset, an in-depth context-specific assessment of the utility for digital technology and big data, and value the differing perceptions and perspectives on the value of digital technologies and digital transformation.
- The emerging digital future requires a fundamental effort to advance data literacy of all stakeholders engaged in water security, in order to have a more effective and visible voice in global discourses and to guard against a growing digital divide that would exacerbate inequalities in socially differentiated groups as well as within and between regions. Apply such frameworks to support sustainability by influencing water culture in general, including consumer behaviour, policy planning, environmental protection, business intelligence, pedagogy, public and private finance and investment-related activities as well as water-related politics.
- Stimulate and foster innovations in water institutions, governance through innovative, cyber based applications.

The water science community that convened in Bengaluru is committed to working with all stakeholders to realize the action plan outlined above.

2. Note for Standing Committee (Integrated Mountain Initiative) of Parliament on Water Resources

Takeaways from Water Future Conference

Introduction:

The Indian Himalayan Region (IHR) covers 9 states namely Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and hill regions of 2 states viz. Assam and West Bengal and the newly formed UTs of J&K and Ladakh of the Indian Republic. Home to 46 million people as per the 2011 census, IHR starts from the foothills in the south (Siwaliks) extending to the Tibetan plateau in the north (trans-Himalaya) comprising about 95 districts of the country. The region occupies the strategic position of entire northern boundary (North-West to North-East) of the nation and touches almost all the international borders (7 countries) with India. It contributes about 16.2% of India's total geographical area, and most of the area is covered by snow-clad peaks, glaciers of higher Himalaya, dense forest cover of mid-Himalaya.

There is now a growing recognition and demand to compensate the IHR for the ecosystem services of provisioning, regulating and cultural services through Green Bonus/Payment of Ecosystem Services (PES). However, though there is an increasing recognition given to the services provided by the IHR, IHR is also reeling under climate stress. This is a state of dichotomy as climate crisis will reduce the value of services provided by IHR to the entire nation.

The recent High Panel Parliamentarians/ Legislators Dialogue at the Water Future Conference held in Bengaluru organized by Integrated Mountain Initiative (IMI) supported by Divecha Centre for Climate Change (IISc) and IHCAP raised this dichotomy with a special focus on the increasing water security challenge in the country. The High Panel roundtable was attended by Legislators across the IHR and distinguished luminaries from national and international institutes of excellence including Future Earth and Global Water Futures. Legislators warned that water wars have already begun as glaciers have started receding, reducing the water flow at source/ springs. This meet recognised the importance of a multi-pronged approach involving all stakeholders from problem identification to co-creating solutions and implementation. The scientific community showed the urgency to work together with the decision makers and the communities on these issues as it is no longer an epoch of climate change but one of climate crisis.

IHR's significance:

Himalayan states provide critical and high-value ecosystem services through its forest cover (India's 33%), huge carbon sink (India's 33%) and serving as the nation's water reservoir providing annually 1,200 billion cubic metres of water through its rivers, among other things.

However, the IHR with its fragile ecology is undergoing stress with increasing urbanization and changing climate. The problem of policymaking is compounded by the fact that within the IHR, there are differences in the key issues depending on geographical location (Eastern IHR or Western IHR) and altitudes (High altitude or middle altitude). IHR is witnessing an average of 100 million tourists every year which is set to only grow in the coming years putting huge stress on its carrying capacity. To exemplify this stress, the Ladakh Ecological Development Group's assessment shows that the average use of water by a local resident in Ladakh is 25 litres per day whereas each tourist consumes 75 litres per day. The number is significant for a place like Ladakh which is a water deficit area and is mostly dependent on snow/glacial melt and Indus river flow. This issue was raised by Mr. Rigzin Spalbar, Ex Chairman Leh Ladakh Autonomous Hill Council. It is also important to note here that the problems of the Western and Eastern Himalayas are very different. Mr. H. Shangpliang MLA Mawsynram said Mawsynram in Meghalaya no longer holds the title of the wettest planet on earth but despite having high rainfall, Meghalaya is facing water deficit issues due to its topography and high run-offs. Similarly, Pu C Lalrosanga, MP from Mizoram brought attention to the fact that the soil typology in Mizoram is very porous leading to huge run-offs due to its less water holding capacity and poorly developed conservation techniques.

Key Points:

1. Need for an integrated approach

The High Panel discussed that the very first step is an integrated policy directive of States which aligns with the national objectives keeping in mind local solutions to local problems. The task is huge, and departments alone cannot solve and mitigate the problems. There needs to be a multi-departmental and multi-institutional synergy along with civil society organisations and grassroots engagement to identify local problems, co-create solutions and implementations. States like Meghalaya and Nagaland have recently formulated their State Water Policies, Arunachal Pradesh has the Catchment Area Protection Policy and Water Resources Authority Bill but not an integrated Water Policy. Mr. W. Lowang, Minister from Arunachal Pradesh earnestly showed his willingness to take back the lessons learned by other NE states in formulating their Water Policy. Similarly, Ladakh doesn't have a water policy in place but its traditional wisdom to preserve water is strong. Such knowledge should also be taken into consideration while formulating water policies in the region.

2. Prioritization

In view of the increasing stress on water resources of the IHR, a call for prioritisation was raised by different stakeholders including NITI Aayog to revive and rejuvenate springs as the lifeline of water resources and control/ check glacier melt. These two issues need to be taken up as priority areas. As per a NITI Aayog report, 50% of the springs in the IHR are drying up which has affected thousands of villages that depend on natural spring water for domestic and livelihood needs like drinking water and irrigation. Almost all mountainous regions of India have reported decline in the number of functional springs. For example, more than 83% of springs have dried up in Almora, Uttarakhand and

water production from half of Sikkim's springs have reported reduction in water flow. But despite this, these springs have not received due attention and continue to dry up due to increasing demand for water, ecological degradation of the mountain areas and unsustainable land use. It has been suggested that an inventory needs to be created urgently for all the IHR states identifying mountain springs- active and dormant, along with detailed geological mapping to identify the spring recharge zone.

3. Water Security for India (North)

The IHR is becoming increasingly vulnerable to chronic water stress, hydrological disruptions, and extreme weather events (floods and droughts) which are becoming a common feature. This is highly alarming given that the Himalayas are the source of three major transboundary river systems of the Indus, Ganges, and Brahmaputra that collectively support an estimated 700 million people. The future of water security in all of India depends heavily on Himalayan glaciers, rivers and on the health of mountain springs and streams. The proper management of our limited water resources is of paramount importance to ensure food security for our increasing population and to avoid the possibility of social unrest emanating out of water conflicts.

4. Principles Governing Water

The carrying capacity of mountains needs to be looked into first and foremost before formulating any policy to govern water resources. The integrated approach upheld considers IHR resources as commons and its ecosystem services should cater in a sustainable way keeping the principle of equity in mind. It has become highly imperative for stakeholders to realise that rights come with responsibilities and engagement with top to bottom is the only way forward. MLA Ferlin Sangma from Meghalaya stated that Meghalaya has taken capacity building exercises for the local communities, sensitization programme for legislators and grassroots workers to implement the water policy on ground. Mr. M. Kikon, MLA from Nagaland raised the issue of empowering Water Users Association through clear directives and information sharing to improve monitoring of water usage. Mr. Z. Namchoom, MLA from Arunachal Pradesh mentioned that the state is starting to feel the heat of climate change and have thoughtfully budgeted for spring rejuvenation. Mr. Pradeep Tamta, MP Rajya Sabha rightly raised that the crisis in the IHR is a national crisis and not just of the Indian mountain States. The discussion ended acknowledging the fact that it is no longer the time to calculate who is correct but what is correct as the right way forward.

5. How to engage

The Divecha Centre for Climate Change at IISc and Integrated Mountain Initiative collaboratively propose to engage with the Standing Committee of the Parliament on Water Resources bringing in stakeholders from the scientific community, decision makers and grassroots to holistically look into the issues of climate change and water security of the Indian Himalayan Region as a way forward. For this, an action plan needs to be developed and water policies related to the IHR needs to be reviewed. The scientific community and civil society organisations are ready to work together with the government to make this task possible.

VII. Inaugural Ceremony

Fig 4: Inaugural session of the Global Water Future Conference on 24 September 2019 at the J. N. Tata Auditorium.

On 24 Sep 2019, the Inaugural Ceremony was held at J.N. Tata Auditorium, Indian Institute of Science, Bengaluru. The session was co-chaired by Dr. András Szöllösi-Nagy, Chair, Sustainable Water Future Programme and Prof. S. K. Satheesh, Director, Future Earth South Asia and Chair, Divecha Centre for Climate Change, Indian Institute of Science. They were joined by other dignitaries, Prof. Anurag Kumar, Director, Indian Institute of Science, Mr. Rajiv Pratap Rudy, Honorable Member of Parliament, India, Mr. Md. Shahiduzzaman Sarker, Honorable Member of Parliament, Bangladesh, Mr. P.D. Rai, Former Member of Parliament, India, Prof. Olcay Ünver, Vice Chair, UN-Water, and Prof. Anik Bhaduri, Director, Sustainable Water Future Programme, who were guests of Honor.

Prof. Anurag Kumar delivered the welcome speech. He deliberated on climate change and how it affects humanity especially in developing countries such as India. He spoke about the water situation in India and the criticality it currently faces. He stressed the need to implement measures to mitigate the contamination of water resources as early as possible. He hoped that this conference will formulate methods and solutions to address the current global water predicament and provide a solution to the academics, water practitioners, policy makers, scientists, civil societies and government officials. He concluded the talk by saying that the outcome of the conference will be a valuable input to the water summit in Budapest.

Prof. Satheesh talked on some of the major achievements and accomplishments of Divecha Centre for Climate Change. He spoke about the

Future Earth South Regional Office and its programs such as MAIRS and the setup of water solutions lab. He pointed out the challenges of water crises and the importance of sustaining water. He urged for indulgence of diverse decision makes in the government, private sector industry, and civil society. He emphasized the need for understanding the water-energy nexus which is central to sustainability. He concluded his talk by indicating that the Centre is working in unity of both physical and social sciences to develop new initiatives for sustainable development under changing climate.

Dr. András deliberated on the importance of water crises which is a major cause of worry for scientists. He said that the current water management practices are not sustainable and that new initiatives need to be implemented if we need to sustain water. This is due to the population boom which is occurring exponentially. Hence the need for developing new tools such as pattern recognition, artificial intelligence, machine learning and all new techniques that can give us hope for the current situation is very important. This exponential rise of population gives rise to other problems that is if it goes beyond tipping point then the change is irreversible. Currently we are at the point of no return in terms of biodiversity. Climate change is influenced by hydrological cycle, if this cycle accelerates then the climate change is also extreme. He questioned as to what science can do to resolve the problems of water such as too little water or polluted water. Water is more of a social problem and we need to work with social scientists to resolve it. It is also a political problem and hence we need to reduce the gap between political and scientific community which is also one of the main objectives of this conference. COMPASS or Comparative assessment of the water

Fig 5: Prof. Satheesh, Director, Future Earth South Asia and Chair, Divecha Centre for Climate Change, Indian Institute of Science, delivering the talk at the Inaugural session.

Fig 6: Prof. Anurag Kumar, Director, Indian Institute of Science, and Mr. P. D. Rai, Former Member of Parliament, delivering their talks at the Inaugural session.

resources and Water Solution Labs where theoretic knowledge developed by scientific community is applied, are two major initiatives to assess the current global water crisis. A third initiative Global Lake assessment program is being put in practice to assess lakes. He concluded his talk by laying out the need for moving towards a digital water management and discussing the various possibilities to achieve it.

Mr. P.D. Rai proposed that as politicians we should look into the water future for the young generation and start framing water sustainability into ideology. Politicians have had communism, capitalism, and liberalism as ideologies. Similarly, such ideologies have to be built for water sustainability on the planet for our lives. He spoke about the issues of water law in India. Laws that govern water have always been political and is run by the states and not central which is detrimental. The water law can be run by state along the model act which has been put out by the Central government. It is important to look at water law and regulation from the point of equity, ethical and cultural. He concluded his talk by saying that the United Nations paradigm are the sustainable development goals and if we follow these goals especially SDG number 6 which is water and sanitation then it will begin in terms of adaptation as well.

Mr. Rajiv Pratap Rudy talked on climate change and spoke about how people in rural areas found about climate change due to erratic changes in monsoon rains and extreme heat waves. He said that people in India still have not yet understood the impact of climate change but one aspect that is hassling the people is water. He pointed out that this environmental aspect of water crisis can be used as a factor to educate them about climate change. Different government department of ministries that handles various projects such as irrigation projects, dam projects, clean Ganga, drinking water and a few more have been merged into one called the Janshakti Mantralaya. He spoke about some of the challenges faced by politicians in India with aspect to water. He talked about visible changes that needs to be addressed such as the snow cover in the Himalayas are not filled in recent years and have patches. He talked

Fig 7: Honorable Member of Parliament, India, Mr. Rajiv Pratap Rudy and Honorable Member of Parliament, Bangladesh, Mr. Md. Shahiduzzaman Sarker, delivering their talks.

about floods occurring at lower areas of states because of trees being felled in the upper regions and states of Himalayas. He cited that we have not been able to channelize the river water in India due to which there are many disputes going on. Water management which is very important is not good in India. Population growth, removal of forest growth due to timer, soil erosion and other disasters are mainly caused by floods. He concluded his talk by saying that scientists need to educate the politicians and that the scientific language is very difficult to understand by the politicians. He urged the scientists not to complicate law by putting in calculus formula and come up with solutions to the current water crisis.

Mr. Md. Shahiduzzaman Sarker spoke about water related disasters and crisis in Bangladesh. He said that the intensity of these natural disasters is increasing every year due to which Bangladesh is one of the worst affected countries as a consequence of climate change. The main goal of Bangladesh delta plain is to ensure that water, food security, economic growth and environmental sustainability will effectively cope with climate change through integrated strategy, adaptivity and equity water governance. He concluded his talk by saying that Bangladesh and India can work together by improving the bilateral relations between the two countries and by building a flood forecasting and warning system.

Prof. Olcay Ünver appreciated India to take on the challenge on the issues of water and sanitation and the remarkable progress that is being made. He also admired the Indian Prime Minister, Mr. Narendra Modi for receiving a global award recognised by the international community of the innovative approaches made by India where the Prime Minister gave a speech on the water conservation and called for a global water action agenda. He said that the UN is coordinating mechanisms for water and sanitation issues. These mechanisms have grown out of many UN agencies, funds, programs and secretariats as there is no single entity in UN system that specialises in water. The UN water brings together the collective expertise and synergies

Fig 8: Prof. Olcay Ünver, Vice Chair, UN-Water, and Prof. Anik Bhaduri, Director, Sustainable Water Future Programme, delivering the talk.

of its 32 UN agency members and their 40+ partners. He spoke about the crisis of water that cost many lives every year. He spoke about the impacts affecting the entire society and their economies. He questioned on how we can balance the demand for water due to population rise in the next decade and fulfil every human right to water resource. He said that the currently the world is off track to sustain SDGs goal number 6 and many countries are facing water issues from increasing water scarcity, water disasters and from inadequate access to safe water and sanitation. If we want to sustain SDG number 6 then we must address the following three areas. 1. Access to water, sanitation and hand washing; the lack of these keep people in the viscous cycle of poverty and can be drivers of conflict and destabilising politics. In addition, loss of productivity due to lack of water and sanitation and illnesses. 2. Water pollution eco systems and agriculture; pollution is worsening in many parts of the world with profound impacts on the quality of water. The loss of wetlands has a massive impact on the environmental stability and agriculture puts enormous pressure on water. The global population and changing lifestyle add to the complexity. 3. Funding, governance and capacity; 80% of countries say that they have insufficient funding to meet national targets. Political, institutional and administrative practices and processes are inadequate. In many countries a serious lack of human capacity across the water security is constraining progress particularly in the least developing countries. He said that we must tackle the crisis now or we will undermine the sustainable development. He pointed out three tangible solutions that can help move forward to attain sustainability. First is to gain understanding which means to understand the linkages between all of the goals and harness their synergies while managing any potential conflicts. We also need to monitor more and get some data to find out where we are failing and help countries make infirm decisions that can steer policies and direct finance. Second is planning better which means that governments must decide how to incorporate SDG targets to national planning processes, policies and strategies taking into account their

local circumstances. We also need to create multi stakeholder partnerships and strengthen regional integration, while ensuring inter sectoral policy making structures across several ministries and public, private and civil societies. The third point is taking action. We have to intensify water and sanitation as well as climate smart environment friendly agricultural development, sustainable guidelines, nature-based solutions and responsible consumption. We also need to significantly reduce food loss and waste using the entire action spectrum from awareness campaigns and tariff regulations to new financial models. We have to ensure public participation and develop human and institutional capacity and make better use of smart technologies and data. He concluded his talk by saying that young generation such as Greta Thunberg is demanding action, we can collectively make a difference and shape the future together.

Prof. Anik Bhaduri spoke about the Sustainable Water Future Programme. He spoke about the structure and vision of this program and what its objectives are. He expressed his concern on how the growth in complexity of water issues have changed the dimensions and scope of scientific advancement. One concern is the rate of change has increased and second is the interactions between water systems locally and globally have gone beyond scientific capability. This is causing a great risk of water resource and hence water management is important to predict and minimize these risks. He concluded his talk in accordance with Dr. András's point of view on digital water science and technology and indicated that more solution labs be set up at local level to achieve results faster and integrate these labs at a global scale.

Fig 9: Inaugural session of the Global Water Future Conference on 24 September 2019 at the J. N. Tata Auditorium.

VIII. Plenary Sessions

1. Advanced Water System Assessment to Address Water Security Challenges of the 21st Century

Fig 10: Plenary session of the Global Water Future Conference.

The opening plenary of the water future conference was on advanced water system assessments with an aim to address the water security challenges of the 21st century. This session was chaired by András Szöllösi-Nagy (Water Future). The first speaker Charles Vörösmarty (Water Future) spoke about how the COMPASS initiative, a comprehensive assessment system for global water resources can be used to monitor the progress of SDGs. Dr. Vörösmarty's talk was also interspersed with policy implications especially when such technologies enter the market. Alan Jenkins (CEH, UK) addressed the newly emerging tools which could be used for tackling water security problems. Dr. Jenkins observed that the global issues associated with reliable water availability might be engineering problems rather than a water security issue. He also spoke about the HydroSOS initiative, which is used to monitor and predict freshwater hydrological conditions on a global scale. Stuart Bunn (ARI, Australia) discussed his work on water resource planning at the Murray-Darling Basin in South-eastern Australia. The next speaker, Veena Srinivasan (ATREE, Bengaluru) shared her insights about the Cauvery basin. Dr. Srinivasan also spoke about the reasons for groundwater scarcity and the biophysical processes which might be the hidden drivers. She also highlighted the science-policy gaps and the need for communication of scientific data. The last speaker, Pradeep Majumdar (IISc, Bengaluru), spoke about the increasing demands on water resources in India and how factors like climate change, population growth and urbanization will likely exacerbate the water security problem.

2. Water and Climate Change: Challenges

The second plenary session on the challenges of water and climate change was moderated by Shailesh Nayak (National Institute of Advanced Studies, Bengaluru). The first speaker Dietrich Borchardt (Water Future) discussed the challenges of extreme events of which extreme hydrological events, in particular, control water shortages as compared to long term aridity, and thus impact the ecosystem. He called for the development of the next generation of monitoring networks and assessments through technological innovation. John Pomeroy (Global Water Futures, Canada) discussed the challenges of water and climate change in the context of Canada and how MEC-Surface & Hydrology System (MESH) and Canadian hydrological models are helping with continental-scale hydrological modelling and water management. Karen G. Villholth (IWMI, South Africa) highlighted that the impact of climate change on groundwater requires a historical understanding vis-a-vis recharge, quality, flow path etc. Dr. Villholth called for a need to update the global circulation models to take into account the groundwater processes to better understand the impacts on aquifers. She also called for better management of aquifer resources for better resilience. Olcay Ünver (UN-Water, Italy) elaborated on the UN water policy brief on climate change and water which describes 5 actions ((1) Act now; (2) Consider water as part of the solution; (3) Improve water management practices; (3) Ensure transboundary cooperation in adaptation; (5) Rethinking financing) for significant co-benefits for the climate and for water. Sharad Jain (National Institute of Hydrology, Roorkee) described the challenges of water and climate change in the Indian context. Dr. Jain discussed the flood events that have occurred in India during 2000-2018, warming in the snow and glacier-covered in the Northern Himalayan rivers and monsoon patterns in various parts of India. Dr. Jain called for a holistic approach for water management and decoupling of the use of resources with growth

3. Role of Big Data, AI, Blockchain Technology in Water Diagnostics and Governance

The third plenary session on the role of big data, AI and blockchain technology in water diagnostics and governance was chaired by Amy Leurs (Future Earth). She addressed the crowd by sharing her expertise with new technologies in water supply and delivery. The first speaker, Nagaraja Rao Harshadeep (World Bank, USA) presented interesting use cases of disruptive technologies such as the spatial agent app developed by the World Bank that offers access to interactive maps and charts of national and international datasets. The next speaker, Venki Ramachandran (Xylem, India) started by explaining the basics of blockchain technology followed by how such a technology is used to trace the flow of water from the source to every point in the network. He also discussed how water meters, coupled with a crediting system, could be used to monitor existing consumption habits and incentivize consumers through

differential pricing slabs. Katrina Donaghy (Civic Ledger, Australia) presented her work on using blockchain technology for publicly regulated water marketplaces. She highlighted how technology could bring transparency and improve people's interaction with the government.

The next speaker, Yadati Narahari (IISc, Bengaluru) discussed an economics approach towards water distribution solutions. Dr. Narahari presented game theory and mechanism design integrated over a blockchain platform to address the problem of water distribution. The final speaker, Balázs Fekete (CUNY, New York) elaborated on employing advanced computer technologies like GIS and remote sensing for hydrological studies. Dr. Fekete highlighted how highly specialized GIS could be used to study gridded river networks and for complex modelling.

4. Global Water Governance: Challenges

The speakers in the fourth plenary session discussed the challenges in global water governance. The chair, Ravi Narayanan (Asia Pacific Water Forum, India) set the context by highlighting that harmony amongst governance; science and technology; and capacity will drive change. Anthony Slatyer (Water Policy Group, Australia) emphasized that immediate and quick action needs to be taken by governments in terms of prioritization, policies and decision making for effective management of water. Claudia Pahl-Wostl (University of Osnabrück, Germany) spoke about the need for the development of a conceptual-methodological research approach framework for transforming a multilevel challenge like water governance, role of climate change as agents in bringing about a transformative change, changing roles of first nations, and nexus approach towards integrated governance.

Håkan Tropp (OECD Water Governance Programme, Sweden), introduced the OECD principles of water governance that guide in determining what works at different scales (country/city) in terms of implementation and best fit. He urged for better understanding of the multilayer of solutions nexus to come up with lasting solutions for the future. Robert G Varady (University of Arizona, USA) discussed the exigencies of transboundary water security and the key role played by community resilience in transboundary water security issues. Sharachchandra Lele (ATREE, Bengaluru) highlighted the lack of emphasis on biophysical and social justice in SGD6, which focuses more only on the quality, availability and sustainability aspects. Indicating a democratic deficit in the water sector due to the lack of decentralization in the system, he recommended an analysis of how water is being governed across institutional layers. William Young (World Bank, USA) emphasized that rather than focusing on the processes, there is a need to focus on the outcomes when we are dealing with water – outcomes that we get from water now and outcomes that we could get in the future when different interventions are made in infrastructure and governance.

5. India Water Security: Key Issues

The final plenary session on key issues regarding water security in India was moderated by Anik Bhandari (Future Earth). The first speaker MS Mohan Kumar (IISc, Bengaluru) gave a summary of the surface level water availability in India and the water scarcity threat associated with overexploitation of surface water. Aditi Mukherjee (IWMI, New Delhi) spoke about the role of groundwater in the context of water-energy-food nexus. Dr. Mukherjee talked about the link between water and food security and highlighted some key issues related to depletion and scarcity of groundwater. The next speaker, Shaminder Puri (Water Future) addressed the country's groundwater as a hidden treasure. He explained the process of aquifer recharge using a lucid bank account analogy and outlined some critical steps to ensure water security. They included efficiently managing aquifer recharge, converging science with socio-economic and cultural conditions, and employing a new underlying philosophy of low water use. Anil Kulkarni (IISc, Bengaluru), a glaciologist spoke about the state of the Himalayan cryosphere and how it is changing. He gave a primer on the major glaciers in the Himalayas, including the Karakoram ranges, and how climate change can influence the cryosphere and their melt-off rates. The next speaker, H Paramesh, a paediatric pulmonologist (IISc, Bengaluru) spoke at length about the connection between water and health. He also highlighted the role of medical professionals in environmental issues. The final speaker, Muthukumara Mani (World Bank) spoke about climate change and its effects on communities around the world. He

Fig 11: Final plenary session of the Global Water Future Conference on 27 September 2019.

explained how rapid urbanization might lead to water scarcity and conflicts and the economic impact of such events. He listed a mix of solutions that need to be employed on our way forward, which included 1) increased agricultural productivity using drip irrigation and climate-smart agriculture techniques 2) applying new machine learning and blockchain technologies for efficient allocation and distribution of water 3) stringent water quality management.

IX. Special Sessions

1. Report by Integrated Mountain Initiative and Ground Water Future

Session SS3: Integrated Session on "Climate Impacts on Global Mountain Water Security" and "Water Solutions for the 21st Century in the Indian Himalayan Region (IHR)"

Global Water Future (GWF) and Integrated Mountain Initiative (IMI)

24 September 2019, Ceres,
Sheraton Grand Hotel, Bengaluru

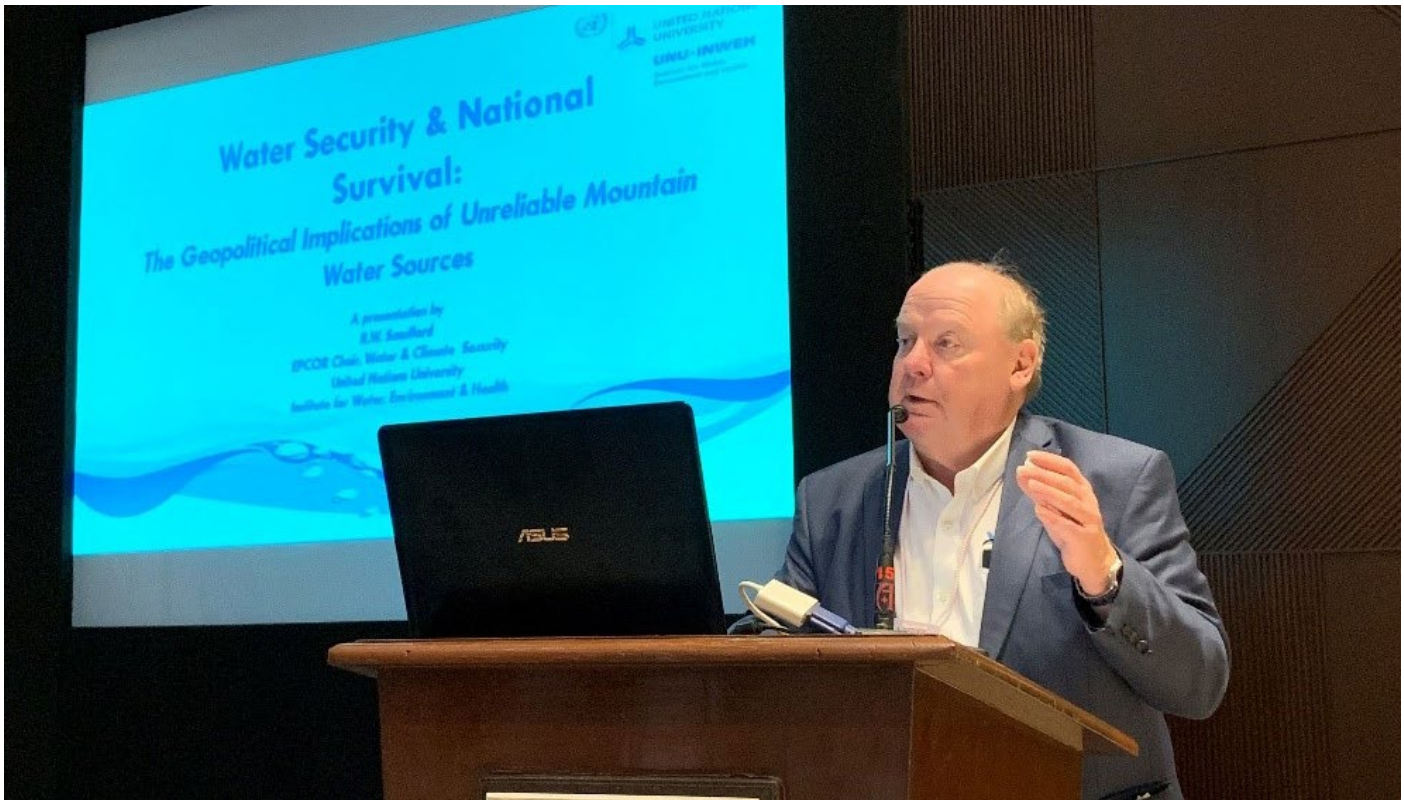

Fig 12: Robert Sandford, Institute for Water, Environment and Health (INWEH), United Nations University, Hamilton, Canada, delivering the talk duing session A.

Session A: Climate Impacts on Global Mountain Water Security, Global Water Future.

1. John Pomeroy, Director, Global Water Futures, University of Saskatchewan, Saskatoon, Canada

2. Robert Sandford, Institute for Water, Environment and Health (INWEH), United Nations University, Hamilton, Canada

3. Ignacio Lopez Moreno, Institute for Pyrenean Ecology (IPE), Spanish National Research Council (CSIC), Zaragoza, Spain

4. Dhiraj Pradhananga, Dept. of Meteorology and Hydrology, Tribhuvan University, Kathmandu, Nepal

5. Chris DeBeer, Global Water Futures, University of Saskatchewan, Saskatoon, Canada

6. Dr. Corinne Schuster-Wallace, Water-health researcher for Global Water Futures

Session B: Water Solutions for the 21st Century in the Indian Himalayan Region (IHR).

1. Vulnerable Smaller Water Resources: evidence of diminishing discharge of spring-flow, declining trends of monsoon rainfall and recent land use changes in Mid-Himalayan Mountain, India- Soukhin Tarafdara and Subhashis Duttab : G.B.Pant National Institute of Himalayan Environment & Sustainable Development, bDepartment of Civil Engineering, IIT Guwahati, Guwahati – Assam

2. Decentralized Water Governance Model in the Central Himalayan Region of India- Vinod Kothari, S.T.S Lepcha and Sunesh Sharma

3. Seasonal water quality variations of palustrine wetland of Barrack- Chindwin basin: Chongpi Tuboi, Michelle Irengbam, Ruchi Badola, Syed Ainul Hussain (Wildlife Institute of India, Dehra Dun)

4. Conservation planning in human dominated riverscapes: case study of Ganga: Michelle Irengbam, Shivani Barthwal, Niladri Dasgupta, ruche Badola & Syed Ainul Husain, Wildlife institute of India, Dehra Dun

5. Climate change vulnerabilities of rapidly growing cities in the Himalaya and policy interventions for mitigation with special reference to Gangtok and the Teesta river basin: P. D. Rai and Rajendra P. Gurung, ECOSS, Gangtok

6. Presentation on Meghalaya's Integrated Water Policy – Mr Aiban Swer, Director,

Conveners:

John Pomeroy, Director, Global Water Futures, University of Saskatchewan, Saskatoon, Canada, john.pomeroy@usask.ca
Chris DeBeer, Science Manager, Global Water Futures, University of Saskatchewan, Saskatoon, Canada, chris.debeer@usask.ca

Fig 13: A presenter presenting during session B.

Session A Summary:

Mountain regions provide water resources that supply over half of the world's population. The issues of climate and cryospheric change, and the associated impacts to hydrological functioning and water resources within and downstream of mountain regions globally are therefore critically important. This session focused on a grand challenge for the global community: how to develop a global scientific approach to better understand, predict and manage alpine water resources in the face of dramatically increasing risks?

Three core questions that are central to meeting this Grand Challenge are:
(1) What control does climate change have on the security of mountain water?

(2) What improvements to the global predictability of mountain water resources are possible through improved models?

(3) How do changes in snow, glaciers, frozen ground and vegetation impact mountain water resource predictions?

Speakers and panellists in this session addressed these issues and questions, and presented examples of research and predictive modelling applications from various mountain regions globally, focussing on impacts on the cryosphere and on hydrological systems.

First, Dr. John Pomeroy opened with a description of threats to mountain water, urgency of mountain water research needs, the potential to improve mountain water prediction, and a global plan to address mountain water futures around the world. Dr. Chris DeBeer followed with a presentation on the observed impacts of rapid climate change in the mountain snow, glaciers, streamflow, vegetation and the science needs to better understand, mitigate and adapt to these impacts. Next, Dhiraj Pradhananga gave an overview of the needs from science for water management both now and in the future in the Nepal Himalaya, and how cold regions hydrological modelling can be applied in the Langtang River Basin to address some of those needs. Dr. Ignacio Lopez Moreno described modelling the decoupling of mountain snow regimes from mountain hydrology around the world under future global warming using cold region hydrological modelling driven by atmospheric reanalysis products, and sensitivity of these nival-hydrological regimes to future change in various mountains of the world. Dr. Corinne Schuster-Wallace spoke about vulnerability of community health, impacts on women and water equity to changing mountain water supply and regime, and impact on community sustainability and equity. Finally, Robert Sandford discussed national and global policy and political implications of the destabilisation of mountain water supplies and what we need to build resilience in downstream communities.

A panel discussion followed the presentations. This included quick questions from the audience (5 min) and roundtable (2 min each) on how our findings relate to our key question: How to develop a global scientific approach to better understand, predict and manage mountain water resources in the face of dramatically increasing risks?

In general, some of the key needs centered on
(1) open sharing and accessibility of

observations and data
(2) improvements and physically-based Earth system modelling and climate model downscaling

(3) better opportunities for education, training, knowledge mobilization, and the informing of policy by science.

Policy and practice require input from local communities and those directly affected by climate and Earth system changes, and must incorporate local tradition, knowledge, and beliefs to succeed.

Dr. John Pomeroy, Director, Global Water Futures, University of Saskatchewan, Saskatoon, Canada

Global water security background:

Water crisis is looming large in the world. By 2030, half of the population will be living in areas of high-water stress. Currently, around 85% of the human population live in arid areas. Increasing stress on water availability is leading to conflict and water-wars. 6-8 million human beings are killed each year from water related diseases and disasters. With already depleting water sources, there is increasing inequality in regard to access to water. 750 million people lack access to safe drinking water, while nearly 2.5 billion lack access to adequate sanitation.

Global importance of mountains:

Mountains occupy 24% of the Earth's land surface and 1.2 billion live in it. Mountains provide more than half of humanity with water for drinking, irrigation, industry, food and energy production. Mountain ecosystems also regulate climate, air quality, and water flow. Their glaciers and ecosystems provide some of the clearest indicators of this global phenomenon. A high proportion of the world's cultural and ethno-linguistic diversity is found in mountain areas, representing the legacy of human habitation and adaptation in these challenging environments.

Global mountain water security challenges:

Increasing degradation of water quality due to agricultural run-off, industrial waste and sewage discharge. Trans-boundary competition for water resources. There is now increasing risk from extreme events – heavy rainfall, GLOFS, rapid snowmelt. Mountains are highly at risk because concerns are amplified due to its vulnerability/fragility.

However, there is a dichotomy of sustenance and risk for mountain water security. Despite all its provisioning services, it is highly under risk. Recent mountain flood deaths and damage from unprecedented precipitation – for example 8225 deaths reported from heavy mountain rains since 2010 in Pakistan, Afghanistan, Nepal and India.

John Pomeroy asks key questions:

1) How can scientific results be mobilized so that they are relevant for decision making in mountain and downstream societies?

2) How can we promote decisions supporting sustainable development under conditions of rapid human development and concomitant cryospheric and climate change?

Sustainable Water Futures Programme: Activities and Outputs

- Climate change scenarios and hydrological model forcing data downscaling;
- Scenario generation for atmospheric and hydrological models over high mountain regions;
- Scenarios and sensitivity analyses to examine impacts on water availability (e.g. timing, magnitude, and duration of flows) and better understanding and predicting water management concerns.
- Relating these results to mountain communities for decision support to provide for sustainable development, including local ecosystem services and downstream water use for communities, energy and food.

INARCH: International Network for Alpine Research Catchment Hydrology

Objectives:

To better

- understand alpine cold regions hydrological processes,
- improve their prediction,
- diagnose their sensitivities to global change, and
- To find consistent measurement strategies.

The World Meteorological Organization (WMO) is convening a High Mountain Summit to foster high-level dialogue and engage decision-makers and local actors to develop a roadmap to science-based, user-driven knowledge and information systems supporting sustainable development and risk reduction in mountain and downstream regions. WMO High Mountain Summit, Geneva, 29-31 Oct 2019.

Robert Sandford, EPCOR Chair, Institute for Water, Environment and Health (INWEH), United Nations University, Hamilton, Canada

Water security and national survival: The geo-political implications of unreliable mountain water sources. Threat of the declining earth system: Planet regenerates through its biodiversity. The WWF living planet report of 2018 states habitat loss as the major threat to biodiversity out of many causes such as habitat degradation, exploitation, invasive species and disease, pollution and climate change.

Most climate feedbacks involve water. If we follow water, we will find the answers to climate change. Mountains being the source of most rivers will soon become geo-political prizes. Time has come to follow the water crisis to avoid the planetary crisis. Climate is heating up very fast and the political community is not acknowledging it equally. Quotes Antonio Guterres from COP24 “To waste this opportunity would compromise our last best chance to stop runaway climate change. It would not only be immoral; it would be suicidal.”

Looking at the Sustainable Development Goals seriously has become an imperative. Youth have risen in the Climate protest and on the other hand there is increasing societal divisiveness. Following a record-breaking heat wave in Europe in 2019, Greenland faced massive heat spike dramatically extending glacial

melt. Humanity is ill prepared to deal with change of this scale. With it, goes the human face of climate change. The indigenous and vulnerable communities shall be the most affected and they do not have a voice. We can reduce and moderate by protecting water resources at the local level most effectively. We are no longer in a state of who is right but what is right.

Ignacio Lopez Moreno, Institute for Pyrenean Ecology (IPE), Spanish National Research Council (CSIC), Zaragoza, Spain

Increasing water temperature impact hydrology by altering river regimes, reduced spring freshet etc. "The largest changes in the hydrological cycle due to warming are predicted for the snow-dominated basins of mid- to higher latitudes, because adding or removing snow cover fundamentally changes the snowpack's ability to act as a reservoir for water storage" (Barnett et al. 2005). But, it has been observed that snowpack and hydrology respond very differently to warmer temperatures in different parts of the world. The links between snow regime and hydrological sensitivity to temperature warming are not well understood yet. This comes from various studies globally which suggests the variability in which snow-packs react to temperature.

Dhiraj Pradhananga, Dept. of Meteorology and Hydrology, Tribhuvan University, Kathmandu, Nepal

Water Resources of Nepal Himalaya: Challenges and Future Research Need: Gives an overview of the needs from science for water management both now and in the future in the Nepal Himalaya. He then explains how cold regions hydrological modelling can be applied in the Langtang Basin to address some of those needs. Nepal had conducted a Participatory Vulnerability Assessment which also captured the voices of people suggesting changes in snow, water sources and soil moisture. But major change has been in precipitation phase. Increase in temperature and unpredictable rainfall patterns.

He brings in perceptions of change in climate and water resources from Keri village of Humla District:

- Bakkhu (thick clothes worn by people in high altitude) replaced by t-shirt and Docha (thick shoes) replaced by slippers.
- There used to be good snowfall in higher altitude but lately, only negligible snowfall.
- Areas that once used to be covered by snow throughout a year are now bare.
- Reductions in crop yields, increase in crop pests and diseases
- Appearance of mosquitoes in the recent years.
- Jackal, monkeys and porcupine in higher altitude destroying crop.

In Nepal National Water and Weather Week, it was brought to light that both excess and crisis can bring conflict.

Maximum temperature is changing at the higher ranges compared to the downstream lower lands. This is bringing challenges in resource management in the mountains. Mountains are not getting the attention as it should, science can help understand the situation. There are significant changes in snow ice cover area in Nepal. Time series images of snow and ice-covered areas in Nepal. More than 50% of snow and ice cover is lost in less than 3 decades. Glacial lakes are increasing in size and new glacial lakes are forming in recent decades.

Future research needed:

- Mountain climates are changing, leading to change in headwater hydrology
- How headwater hydrology is responding to the change in precipitation phase and snow cover area?
- Impacts on socio-economic sectors.
- Identification of traditional knowledge and practices to cope with these changes.

Chris DeBeer, Global Water Futures, University of Saskatchewan, Saskatoon, Canada

Impacts of Climate Change on the Mountains of Northern and Western Canada:

Changing Regional Climate: The western Canadian Cordillera: Dramatic change in temperature, more than the global average. Air temperature trends have shown a clear and coherent rising pattern over western Canada. Precipitation trends: certain areas have witnessed a drastic increase in annual rainfall. Rapid disintegration & fragmentation of many glaciers. Lower parts of many glaciers will be gone within decades or less; larger ones perhaps longer.

Vegetation Responses:

- Changing fire regime—massive fires likely to return many valley forests to grasslands.
- Pine Beetle; example of unanticipated shift to take system in different direction
- Treeline advancement and infilling

Science needs:

- Observations and open data
- Development and testing of models, methods and algorithms
- Education, training, knowledge mobilization, & outreach

Dr. Corinne Schuster-Wallace, Water-health researcher for Global Water Futures

Water gender health- Reflections for high mountain regions

Local Water Security:

Changing threats to local water security is synonymous to changing threats to health in communities. Health is more than the absence of disease. It is a necessity to ensure water of a suitable quality to enable healthy, dignified and productive lives. Rural populations are more dependent on eco-system services with least investment and are far away from decision-making. Policy and practice need the community for sustainable solutions.

Rights bring responsibilities: This is the framework within which Dr. Corinne conceptualizes local water security.

Location and plan are essential in the rights-based responsibilities framework because of the following reasons:

- Rural, remote, and otherwise marginalised communities are most likely to depend on ecosystem services
- Values shaped by reliance on natural resources, local & traditional knowledge, & beliefs
- More strongly tied to where they live
- Least able to invest in prevention or solutions, or actualise resilience
- Voices of the marginalised are not heard
- Policy and practice will not develop sustainable solutions without their input

Women have an unfair burden for the following reasons:

- They are the most vulnerable because majority of the poor are women, illiteracy, disempowered, reliance on public services, lack of access to and control over financial resources.
- Caregivers, fetchers and carriers: Bribes and sexual favours, lack of poorly constructed facilities, high morbidity and mortality.
- Insufficient participation in solutions: Women are "less likely to take decisions that improve their personal wellbeing, and more likely to seek to improve the wellbeing of others"

Principles for Understanding Local Water Security:

- Coupled-systems approach (EcoHEalth)
- Understand both direct and indirect impacts of water on health
- Understand knowledge, attitudes, Practices & Perceptions
- Community-engaged
- Pro-marginalised lens (gender, poverty, discrimination)

Therefore, she urges for research approaches to be:

- Mixed Methods
- Literature, Document, & Policy Reviews
- Water Measurements & Inspections
- Expert Panels, Workshops, & Key Informants
- Geo-positioning & GIS
- Community-based Qualitative Interviews & Surveys
- Community Participatory mapping
- Photo Voice

A Moral and Fiscal Imperative Water Futures for the World We Want:

- Sustainable development imperative
- SDG3: Good health and wellbeing
- SDG5: Gender equality
- SDG6: WaSH, water quality, management
- Leave no-one behind
- Society, economy, environment
- Resource efficiency
- Human right(s)

Session B Summary:

Water Solutions for the 21st Century in the Indian Himalayan Region (IHR)

Vulnerable Smaller Water Resources:

Evidence of diminishing discharge of spring-flow, declining trends of monsoon rainfall and recent land use changes in Mid- Himalayan Mountain, India- Soukhin Tarafdar. Scientific research in ecology as well as hydrology had long produced compelling evidence of strong linkages between the small stream networks, the surrounding landscape and the downstream rivers **(Nadeau and Rains, 2007; Meyer and Wallace, 2001)**. But reckless planning and lack of policies have resulted in impairment of many headwater streams due to excess sediments generated during the rural-road expansion, road widening, recurrent man-made forest fire, landuse change and climate change.

There are growing recent evidence based on regional climate modelling studies **(Halder et al., 2016; Quesada et al., 2017)** that land-use land-cover change could be one of the drivers impacting the Indian summer monsoon. Although, these land-use land-cover change drivers are large-scale forest to agriculture or pasture land conversion. In the past (in the mid-1900s or so), a reverse transformation of conversion of agriculture land to fallow land, reforestation and gradual forest regeneration in permanent fallow and pasture land by fire resistant fast growing species of chir pine ***(Pinus roxburghii)*** is reported from middle mountain region of Uttarakhand, India **(Tarafdar et al., 2019)** as well as in Nepal **(Ghimire et al., 2013; Paudel et al., 2016)**. Enhanced evapotranspirative demand of gradually expanding forest due to afforestation and natural regeneration of chir pine may have aggravated summer water scarcity in already water scarce region of mid-Himalaya facing 'unaccounted' multiple drought years. Moreover, land-use change could bring depletion in soil moisture as reported from other parts of the world **(Deng et al., 2016)**.

Understanding the inherent complexity in climate, hydrogeology in complex topography as well as serious lack of scientific data in Indian Himalayan Region, it will be prudent to shift our focus from traditional soil and water conservation at complex hillslopes unit to storage-based conservation of surplus flow available during the monsoon and post monsoon months. Mission to geo-tagged and rejuvenate the drying springs is ongoing in different states all across Indian Himalaya through vegetative or soil and water engineering methods without really demonstrating the efficacy supported by scientific data. In an era when water is becoming a limiting resource and large-scale alteration of not only landscapes but also streams and river network is underway through rural connectivity improvements projects and damming affecting the ecological sensitive fragile mountain, augmentation of gaging stations of Himalayan Rivers should become the foremost priority. Traditional key smaller water resources should be safeguarded through **Source Water Protection Act** for assuring long-term water supply needs.

Decentralized Water Governance Model in the Central Himalayan Region of India- Sunesh Sharma

Uttarakhand Profile:

Area: 53483 Km Square
Population: 10.2 Million
Water Dependence: 90% on Springs
Land Use: 71% on Reserve Forest

Traditional Water Wisdom:

- Uttarakhand traditionally depended upon its naulas and dharas (seepages and natural springs).
- Over the centuries Uttarakhand has developed its own hydraulic technology, which is quite unique in its usefulness.
- The ancient people of this region evolved the hydraulic technology taking into consideration all the necessary factors which suit the environment of the region.
- The people are well aware of the importance of water; they treated water sources as sacred and many rituals are performed around the water sources.

Policy & Water Rights:

The development of rights relating to water resources in the state can be divided into three periods:

- Pre-constitutional period: This can be described as a period of decentralized governance, when water was considered a common pool resource and rights over natural resources lies with the local community.
- Colonial period: Common property rights were diluted and replaced instead by private property rights. State sovereignty over natural resources was established.
- Post-constitutional period: the Kumaon and Garhwal Water Act, 1975 and the Uttar Pradesh Water Supply and Sewerage Act of 1975 came into being. The advent of these Acts brought the supply of drinking water under the State's objectives. At the same time, customary rights were abolished.

Challenges:

- 60% Springs have been drying up or dried in the Himalayan region (NITI, Ayog 2018) due to various reasons but there is a progressive increase in demand of water.
- Out of 39,202 habitations/ villages in Uttarakhand, only 21,363 habitations/ villages have drinking water facility. For the rest 17,839 villages, there is a water shortage either due to the dried-up water sources or the failed drinking water projects.
- Spring are the lifeline of mountain community but springs as a source of water, do not even mentioned in the National Water Policy of India. While springs are a form of ground water resource, however, there is very little acceptance at policy level.
- In Uttarakhand around 71% of the state's geographical area falls under Reserve Forest (RF), which is technically owned by the government. And many a times springs source falls in the Reserve Forest. To get access to RF for augmentation of spring catchment is a tedious process.
- The cost of providing water security per person in the hills is relatively more as compared to the plains of Uttarakhand. This is because of the lack of road connectivity and difficulty geographical terrain.
- There is no water policy in Uttarakhand till now.

Vision 2020: Enhance the quality of life of over 100,000 HHs of 1000 villages

Evolution of HIMMOTTHAN'S WaSH: Building capacities of various stakeholders on Springshed management through holistic and coordinated effort to create an enabled environment for water based learning and sustainable developmental action.

2019-20:

Scaling up in 650 villages
Water Security in 100 villages
Impacting 35000 Plus Households

Methodology:

1. Base line survey
2. Spring Inventory
3. Hydrogeological Survey
4. Village water security plan preparation
5. Capacity building
6. Institutional Framework & Governance structure
7. Catchment Area Treatment (recharge works) through UWSC
8. Operation and Maintenance
9. Data & MIS

Springshed Management Consortium-Uttarakhand

Establishment: Taking forward the recommendation of Niti Aayog Spring shed management Consortium constituted in September 2018

Objective:

State-wide Springshed Management in Uttarakhand

Outreach: Uttarakhand

Structure: 20 members, line department, NGOs, civil society, experts, etc.

Plan for FY 2019-20:

- Vulnerability Assessment
- Spring Inventory
- Online portal-SMC
- Hydrogeological Survey
- DTR preparations
- Implementation
- M & E

Recommendations:

- A state-wide programme on Springshed Management through Spring Shed Management Consortium (SMC) using Forest-Hydrology approach.
- A Comprehensive plan of spring revival, involving local communities would be useful. The plan must involve capacity building at field level, Data collection, and Monitoring at regular intervals.
- Participation of women and vulnerable section of society leads to better water management.
- Mainstreaming Springshed programmes through a convergence with existing development programmes such as the Annual Work Plan of Forest Department IWMP, MGNREGA and other programmes

Seasonal water quality variations of palustrine wetland of Barrack-Chindwin basin: Chongpi Tuboi

Introduction:

- Wetlands with floating meadows largely occur in temperate and tropical freshwaters throughout the world (Junk, 1973).
- Phumdis, the floating meadows of the Keibul Lamjao National Park are last refuge of Sangai, Rucervus eldii eldii.
- The Ithai Barrage (1983) on Imphal River, has changed the water regime resulting in change of phumdi thickness

and vegetation composition (Kumar et al., 2002; Singsit, 2003).

Study area in landscape perspective Barak-Chindwin Basin:

- The Loktak Lake lies to the western side of the Barak-Chindwin Basin
- Has multiple and often conflicting uses

Loktak Lake:

- Largest natural freshwater Lake in north eastern India
- Area – 287 km2
- The southern zone of the Lake is the KLNP
- Ramsar site – 23rd March 1990
- Proposed World Heritage Site

Resource Dependence:

- Household use
- Agriculture - irrigation
- NTFPs (Vegetables, fodder, fuelwood
- Fishing
- Fish farms (periphery)
- Drinking
- Household use

However, there has been a change in resource use. Fishing and vegetable collection have increased but fodder collection and fuelwood collection has dropped.

Threats:

- Nutrient enrichment of lake water
- Eutrophication, anoxia and succession
- Hydrology alteration
- Restricted flushing and sedimentation
- Unsustainable resource extraction
- Degenerative practices such as phumdi aquaculture

Methodology: Sampling design

- Monthly sampling for two years (Dec 2008- Nov 2010) from 11 sites
- 6 sites in Loktak Lake (5 inlets), and 5 in KLNP (2 outlets)
- Grab samples of water

Findings:

- No significant difference in water quality parameters between the two study years (t-test, $p>0.05$).
- Water quality in terms of key parameters varied significantly across sampling sites (ANOVA, $p<0.05$).
- Across seasons, there was significant variation in terms of EC, turbidity, TS, TDS, hardness, Ca, Mg, Na, K, transparency and temp (ANOVA, $p<0.05$).
- No significant variation in terms of pH, DO, TKN, TP and BOD.

Results:

- The participants of the focus group discussion consensually agreed that
- Water quality has degraded over the years
- Water was used for drinking, besides household, agriculture and fish farming.
- Water use is restricted to seasonal fish farming - February to July – relatively better water quality
- Farmers from Eastern side of the Park mostly rely on river water.
- Local traditional or customary laws or institutions for the utilization and management of the lake is not in place.
- Change in hydrology, pollution, NTFP collection and phumdis proliferation - altered the use pattern.
- Pollution - decrease in fish productivity/catch – fishermen opting for other livelihoods.
- Extra expenditures on purchasing drinking water for household uses,

pumping of fish farm water (fuel, electricity, labour costs).

- Eastern range 5-7 % of the monthly household income
- Other ranges, 10-12% of monthly household income
- Extra time spent on collecting drinking and household use water.
- Hyper-eutrophic condition of the Lake could be attributed to
- Increase in BOD, PO4, NO3
- Subsequent reduction in DO
- Destruction of natural flushing mechanism
- Varifactors obtained from factor analysis indicated that overall variation in water quality was mainly related to nutrient load and soluble salts
- Nutrient accumulation, decreased DO and increased BOD has led to decreased water quality in the Loktak Lake
- Permanent flooding and disruption of natural flushing mechanism of the Lake by the Ithai barrage are major reasons
- Erosion from surrounding catchment area is also contributing to nutrient accumulation
- Livelihood opportunities have reduced putting extra pressure on household economy
- Setting up of local level institutions – capacity building – management of lake resources.
- People are willing to support and get involved in activities of various line agencies and govt. departments
- Stricter implementation of Ramsar Management guidelines and adaptive management through Ramsar Management Effectiveness Tracking Tool.

Recommendations:

- Regulation of water level through consultative meetings to maintain ecological and economical processes.
- Surface runoff could be intercepted through plantations along the bank of the Lake.
- Commissioning sewage treatment plants in Municipal Sewage Management Plan to intercept raw sewage at strategic locations.
- People's participation in lake management and conservation.
- Task Force comprising of local communities for lake management to monitor water quality and water recharge.

Conservation planning in human dominated riverscapes: case study of Ganga: Michelle Irengbam

River conservation planning:

1. Declining aquatic species, 81% from 1970-2012 with an average annual decline of 3.9% (WWF 2016).
2. Linkages between hydrological connectivity and ecological processes (Tockner & Stanford 2002).
3. Off-stream disturbances in addition to in-stream threats **(Linke et al. 2011)**

Human-dominated riverscapes: Ganga river

Threat map: Upper Ganga

Morphological changes, water diversion.

Threat map: Middle Ganga

Water diversion, alteration of riparian areas, sand mining, pollution, unsustainable resource use

Threat map: Lower Ganga

Water diversion, alteration of riparian areas, sand mining, pollution, unsustainable resource use

Objectives:

To critically examine Indian legislation impacting Ganga river conservation

To critically examine the global scenario of river conservation planning

- Scale & impact of threats necessitate urgent strategic actions.
- GoI's renewed emphasis on Ganga restoration has driven the wheel towards science-based conservation approaches.
- Absence of a river policy to facilitate coordinated planning and implementation.
- Spatial and temporal mismatch in planning and implementation.
- High human dependence and strongly linked socio-ecological systems
- The need of exploring ways to ensure maximum conservation benefit in view of the social and economic constraints.

Recommendations:

- Ensuring horizontal and lateral connection through soft protection measures as well as riparian buffers.
- Integration of science-based and policy backed response actions are mandatory steps to achieving conservation goals.
- Improving institutional design and capacities would help develop a platform for sectoral coordination and spatial policy integration
- Sectoral policies need to have an adaptive approach, in sync with the new information and practices from river conservation science.

Climate change vulnerabilities of rapidly growing cities in the Himalaya and policy interventions for mitigation with special reference to Gangtok and the Teesta river basin: P. D. Rai

Introduction:

Climate change-induced global warming is resulting in glacial melt. The retreating glaciers, formation of glacial lakes and outburst floods is an issue. The Teesta river originates from the glaciers and drains through Sikkim into West Bengal.

- This paper will examine the vulnerabilities and hazards from the phenomena of climate change, changes in snow and glacier runoff and frequent cloud bursts.
- The main source of water supply for Sikkim's capital Gangtok comes from glacial melt, monsoon and winter rains and the underground water systems which form springs dotting the landscape.
- How are all these impacting the water security for Gangtok in view of a rapidly growing urban population is a question of worry about.
- This paper will discuss the political economy of water distribution which adds to vulnerabilities.
- The paper will present policy interventions to mitigate water security and recommend measures (policies) to mitigate the impact of climate change on people living in the basin.

IMI and Mountain Cities- Context

Integrated Mountain Initiative [IMI] – Vision of Making India Proud of its Mountains

- Mountain Cities conference in SMDS 2 (2012) & Standalone in

Mussoorie - Mountain Cities 2014, January 20, 2014

- Darjeeling's water woes juxtaposed
- Mussoorie and Shimla as examples too
- Tanker Mafia

The political economy of water in the mountain cities:

- Water is a public good but one which can be traded easily, it is also needed instantly by consumers. If demand is high then extraction of a high price is possible- genesis of problem
- There is the source, the distribution by Government agency
- Citizens, hotels and other institutions
- Competition for water amongst the citizens
- Water Law in India and its development
- World Bank- The role of Political Economy Analysis in Development Policy Operations

Gangtok-

- Population ~ 2,00,000
- Water is sourced from Rateychu [16 km] which is fed from snowmelt and glaciers – and stored in Haans Pokhri and other smaller lakes. See figure [Next slide]
- Tapped to bring in 42 MLPD to Selep Tank for treatment
- It is then distributed [Slide aNer Next]
- About 65 percent residents get water from Selep
- Rest have to get it from urban springs

Distribution of water in Gangtok Municipality:

- Real issues of UFW – Unaccounted For Water – over 80 percent. Inefficiencies
- Not enough distribution nodes
- Funds issues – always waiting for a project to augment supply
- Not real mapping of demand

Problem definition:

- Climate change impacts
- What do we expect
- How do we react
- What are our adaptation

Recommendations:

- Water Law
- Policies
- Sustainable Development Goals- Welfare of Generations Bill
- Sustainability
- Next Steps

Presentation on Meghalaya's Integrated Water Policy – Mr Aiban Swer, Director, Meghalaya Basin Development Authority (MBDA)

MEGHALAYA: WHERE THE CLOUDS COME HOME The Land and its People

Comprising of the Khasi, Garo and Jaintia tribes, spread over 22,429 sq. km, in Northeast India.

- Two of the wettest sites in the world viz., Cherrapunjee and Mawsynram
- Increase in drought affected areas, forest fire, changes in wildlife habitats, migratory routes and stress on flora and fauna
- Climate Change is reflected in flash flood, landslides, excessive soil erosion, and damage to agricultural crops.
- Identifying adaptation and mitigation options in Water Management and other Cross Cutting Sectors

Water and Climate Change:

Highly vulnerable to climate change due to its geo-ecological fragility, landscape and socio-economic profile.

- Its economy is closely linked to its natural resource base
- Land use is changing rapidly
- Climate sensitive sectors like agriculture, water resources, forests, health, sanitation, and rural development affected. Higher temperature, increased rainfall and frequency of extreme weather events predicted
- Management of water resources is critical for adapting to climate change.

The State Water Policy 2019 Finalised by Department of Water Resources, Government of Meghalaya

Paradigm shift in management of Water Resources

- From supply driven to demand driven
- Strong Community participation from planning to implementation
- Focus on Water Users' Associations
- Thrust on Knowledge Creation & Sharing
- Remote Sensing & GIS technology
- Community Driven Development Approach
- Convergence for coordinated efforts

Creation of the Meghalaya Water Foundation and Meghalaya Water Resources Development Agency to assist the Government.

The first Retreat on Water held on July 2013 laid the foundation for the vision, mission and strategic intent.

The second Retreat on Water held on January 2014 prepared to organise the Shillong Water Conclave.

The Shillong Water Conclave, held at Shillong on 22nd March 2014 brought together Water Ministers of North Eastern States, Local Champions of the region, NGO's, WUA's and individuals together with national and international agencies.

Policy Objectives:

- Recognise water as a common resource
- Provide equitable and efficient allocation of water to all
- Provide safe and hygienic water
- Ensure protection and conservation of catchments and promote principle of 3-R
- Enhance resilience to disasters and impacts of climate change
- Ensure convergence of water related interventions
- Promote latest tools and technologies
- Promote community participation in management of water resources.
- Setting up of a regulatory framework to realise the economic value of water.

UNESCO INC-IHP
Report of Brainstorming Session
on
Ecologically Sustainable Water Management: Challenges in Water Scarce Regions

(Theme#5: Ecohydrology- Engineering Harmony for a Sustainable World)

27 September 2019, IISc, Bengaluru

United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

National Institute of Hydrology

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Research. Innovation. Sustainability.

Organized during
Water Future Conference- 2019

By

Indian National Committee for International Hydrological Programme (INC-IHP), National Institute of Hydrology, Roorkee

&

Future Earth

Session Moderators:

Sl. No.	Name and email	Designation
1	Dr. B. Venkatesh	Scientist- 'F', Hard Rock Regional Centre, Belgaum, Karnataka
2	Dr. Jyoti P. Patil jyoti.nihr@gov.in	Deputy Coordinator, INC-IHP Scientist- 'C', RMO Division, National Institute of Hydrology, Roorkee

Keynote Speakers:

Sl. No.	Name and email	Designation	Topic/ Sub Group Focal Theme
1	Dr. Jagdish Krishnaswamy jagdish@atree.org	Senior Fellow, ATREE Foundation, Bengaluru	Sharing water between humans and nature for India's ecological security
2	Dr. Harry Virahsawmy harry.virahsawmy@alluvium.com.au	Urban Water Specialist, Alluvium Consulting, Australia	Focal Area 5.4: Urban Ecohydrology- Liveability and health in cities: What is the role of water?
3	Dr. Bernhard Lehner bernhard.lehner@mcgill.ca	Associate Professor Department of Geography, McGill University, Canada	Identifying priority catchments for water resource protection as a contribution to sustainable development and freshwater biodiversity conservation: a national approach for Zambia
4	Mr. Prashant Dhawan prashant.dhawan@gmail.com	Co-Founder Bio Mimicry, India	Role of biomimicry in ecologically sustainable water management
5	Dr. B. Venkatesh venkatesh.nihr@gov.in	Scientist- 'F', Hard Rock Regional Centre, Belgaum, Karnataka	Measurement and modelling of hydrologic regimes under different land covers in Sahayadri mountains, India

The Sustainable Water Future Programme (Water Future) of Future Earth has organized its first international conference in partnership with Divecha Centre for Climate Change titled "Towards a Sustainable Water Future" in Bengaluru, India. The conference was hosted by the Indian Institute of Science, Bengaluru.

The conference addressed the current state of global water resource challenges, future pathways and scenarios, and different technological, institutional solutions to accelerate the implementation of water-related Sustainable Development Goals and the 2030 Agenda targets with an aim of 'leaving no one behind'. Around 700 participants from all across the globe have attended this conference thus giving a major opportunity for academics, water practitioners, policymakers, scientists, civil society and government officials to discuss the direction that the global scientific community should take in order to solve myriad of challenges affecting our water systems in real time and develop new frontiers for innovative solutions.

Considering this opportunity, Indian National Committee for International Hydrological Programme (INC-IHP), Roorkee organised a brainstorming session on 27th September, 2019 on "Ecologically Sustainable Water Management: Challenges in Water Scarce Regions", which comes under theme#5 of the IHP-VIII i.e. – "Ecohydrology- Engineering Harmony for a Sustainable World". The session was held at Hotel Sheraton and Moderated by Dr. B. Venkatesh, Scientist F and Dr. Jyoti P. Patil, Scientist- 'C' & Deputy Coordinator of INC-IHP. The schedule of the session is placed at Annexure-I. Students, researchers, academic faculties, and officials from various organisations attended the session.

In the beginning of the session, Dr. Patil familiarized the audience with IHP and its activities in India. As International Hydrological Programme had been started in 1975 and implemented on a six-year programmatic time intervals or phases, she also briefed about its eighth phase (2014-2021) and outlined its various themes. As IHP's secretariat is housed in National Institute of Hydrology (NIH), Roorkee, she also discussed the role and responsibilities of NIH in successful execution of this phase. She also talked about various international programmes like- G-WADI, HELP, GRAPHIC, ISARM etc. running under the umbrella of IHP. Lastly, she discussed about Sustainable Development Goals (SDGs), which are to be achieved by 2030.

Dr. Jagdish Krishnaswamy talked about "Sharing water between humans and nature for India's ecological security" which was the first lecture of this brainstorming session. In initial slides, he briefed about SDGs 6, 14 and 15 that mainly addresses water related issues. He specifically mentioned SDG target 6.6, which seeks to halt the degradation and destruction of water-related ecosystems, and to assist the recovery of those already degraded. This target includes water-related ecosystems such as vegetated wetlands, rivers, lakes, reservoirs and groundwater, as well as those occurring in mountains and forests, which play a special role in storing freshwater and maintaining water quality. Further, he spoke about river dredging and channelization for waterways. In his opinion, inter-linking of rivers will adversely affect the aquatic ecosystem. Dredging of river bottoms can

Fig 14: Glimpse of INC-IHP session.

significantly alter sediment deposition and riverine habitats for endangered species, and damage fish breeding grounds. Dredging of sediment may also release pollutants into the river water, including Arsenic. He also showed a case study of estimated submergence of riparian zone due to Ken-Betwa linking. In the end, he emphasised that there is need of adaptive management of reservoirs and barrages to minimize negative impacts on endangered species. All climate change mitigation projects should be subjected to environmental scrutiny and defining ecological flows with clear normative goals in an inter-disciplinary manner for each stretch of the river and link across scales shall also be beneficial.

The second lecture of the session was delivered by Dr. Harry Virahsawmy on the topic "Liveability and health in cities: What is the role of water?" At the outset, he gave the State of Australian Cities, 2013 definition of a liveable city, which says "The liveability of a city is judged by the health, wellbeing and the quality of life of people living within it". Further, he talked about medical care expenses incurred due to the physical inactivity that costs Australia $13.8 billion per year (Medibank, 2008). A significant proportion of this cost can be avoided by incorporating open spaces while preparing an urban plan for a city. Open spaces provide a space to play, relax and exercise that ultimately adds to several health benefits including stimulation of active recreation, contribution to improving mental health etc.

He also discussed the green-blue infrastructure planning and design of a city. This plan aims to recreate a nature-oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together. This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilience and adaptive measures to deal with flood events. In the end, he concluded that green infrastructure influences health and wellbeing. The green-blue planning can be integrated with major healthcare planning, which has significant opportunity to implement at a city-scale.

The third and important presentation of this session was delivered by Dr. Bernhard Lehner on the topic "Identifying priority catchments for water resource protection as a contribution to sustainable development and freshwater biodiversity conservation: a national approach for Zambia". Firstly, he familiarised the audience with the goal of his study and the methodologies adopted for this. For precise and better results, he ranked priority catchments and rivers for the three individual Water Resource Protection Areas (WRPAs) categories namely water provision; important aquatic ecology and sensitive areas. Then he combined the results from the three priority assessments in a multi-criteria analysis.

He also explained these WRPAs categories one by one. Under water provision category, a catchment or river may be an important water resource area, if it is:

- high in land surface runoff,
- within a headwater region,
- the source of water for many people and
- the source of water for agriculture (i.e. – dams).

Under important aquatic ecology category, a catchment or river may be an

important water resource area if it is:

- High in species richness/ biodiversity,
- Important for its aquatic ecosystem function (e.g. – wetlands) and
- Important for river connectivity.

And under sensitive areas, a catchment or river may be an important water resource area if it is:

- At high risk for soil erosion and
- A river with high sediment transport rates (suspended sediments).

Lastly, Dr. Lehner concluded that the method he adopted for this study allows for prioritizing (ranking) catchments and rivers based on their importance as water resource areas in a relatively short time and even in regions with limited data availability. The outcomes are now used by Zambian water resource authorities to inform their next steps towards gazetting WRPAs.

Subsequently, Mr. Prashant Dhawan discussed about the topic "Role of Biomimicry in ecologically sustainable water management". In initial slides, he briefed about geological time scale and how the life forms evolved in water bodies. In his opinion, water is both an operating condition as well as the necessary internal ingredient of life. Further, he discussed the term "Biomimicry", which is the examination of nature, its models, systems, processes, and elements to emulate or take inspiration from in order to solve human problems. Ethos, (re) connect and emulate are three key elements of Biomimicry. He also gave various examples of Biomimicry from natural systems. Mangrove and fishes filter/desalinate water, while by the process of transpiration; plants regulate their temperature during hot conditions. If we talk about desert welwitschia, it uses water judiciously, whereas cactus and palm tree stores water. In his concluding remarks, he emphasized that we should go for natural and place specific solution for a certain problem. We must learn how does nature filter and clean water? How does nature optimise the utilisation of water?

The fifth and last lecture of this session was delivered by Dr. B. Venkatesh on the topic "Measurement and modelling of hydrologic regimes under different land covers in Sahayadri mountains, India". He presented one of his research works about the impacts of changing land cover on the hydrologic regime of Uttara Kannada district of Western Ghats. For this study, he chose Acacia plantations. In the beginning, he gave an outline of the presentation and tried to point out that hydrological effects of afforestation to improve or restore the hydrological behaviour have not been studied yet. Further, he showed his findings that the temporal and spatial distribution of soil moisture is mainly dependent on the soil and land cover. The highest peak flow magnitude was observed in degraded watershed, followed by Acacia in comparison with the forested watershed. Lastly, he concluded that Acacia plantation was very helpful in restoring the hydrologic process which were deteriorated due to degradation of the landscape to the level of natural forest over a period of time and also ameliorate the soil physical and hydraulic properties. It helps in building up of soil moisture and moderates the peak flow and increases the low flow quantities.

The brainstorming session ended by giving mementoes to all distinguished speakers of the session and with vote of thanks.

3. Report by Divecha Centre for Climate Change, IISc

Towards a Sustainable Water Future

A Future Earth Conference

Special Session on Cryosphere and Water Security

25 September 2019, , IISc, Bengaluru

DIVECHA CENTRE FOR CLIMATE CHANGE

विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF SCIENCE & TECHNOLOGY

Waterfuture Conference

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

Organized by

Divecha Centre for Climate Change, Indian Institute of Science, Bangalore, India

Divecha Centre for Climate Change in association with Sustainable Water Future Program (Water Future) of Future Earth has organised an international conference on "Water future- towards a sustainable water future" at Indian Institute of Science from 24th September to 27th September 2019. It was a global platform facilitating international scientific collaboration to drive solutions to the world's water problems. Water security is generally described as the capacity of society to safeguard sustainable access to adequate quantity of quality water. Himalayan cryosphere due to large concentration of seasonal snow and glacier provide sustainable source of water for people living in the mountain and in surrounding Plaines. However, due to climate change Himalayan region is experiencing higher warming than global mean, causing rapid loss in glacier mass and early melt of seasonal snow. In future, this can influence water availability. In addition, retreating glaciers will also create new hazards like flash flood from glacier lakes, influencing safety and livelihood of people living in the mountains. By considering these aspects a special session was organized on 25th September 2019 entitled "Cryosphere and water security".

The session covered three broad aspects as given below.

1) Cryosphere processes, dynamics and climate change

2) Cryosphere: risk assessment, mitigation and communities

3) Cryosphere research and policy making

Based on these themes, we had three sessions as oral, poster and panel discussion. We received 41 abstracts from 18 institutes of India and one from Afghanistan. Out of these 41 abstracts, we have selected 18 as oral presentations and 23 as poster presentations. Latest developments in this area were presented during these sessions.

Panel discussion was chaired by Dr. Akhilesh Gupta, Advisor, Department of Science and Technology and 19 members were invited for that. It was open for all participants of this special session. The topic for the discussion was "How to reorganise glaciological research in India?" Dr. Anil Kulkarni introduced the idea of virtual centre to the participants and followed by Dr. Akhilesh had spoken about the expectations of DST on this aspect. All members have actively participated in the discussion and raised the difficulties in carrying out the glaciological research in India. It was concluded that, a long term national wide network system for the glaciological programme should be needed in such a fashion that of formation of working groups which will be sharing data, equipment and other infrastructure facilities for the smooth research in the field of glaciology.

List of participants:

Sl. No.	Name	Designation	Institute
1	Aditi Bhadra	Associate Professor	North Eastern Regional Institute of Science and Technology, Itanagar
2	Aishwarya Ray	Research Scholar	Dhankula Institute of Engineering & Technology
3	Akshay Patil	PhD Scholar	IIT- Bombay
4	Anant Kumar	SRF	Snow and Avalanche Study Establishment, Chandigarh
5	Anita Chandrasekharan	Research Scholar	IIT-Bombay
6	Arya A.R	Project Assistant	DCCC
7	Ashim Sattar	Assistant Professor	IIT-Roorkee
8	Ashutosh Kulkarni	Project Assistant	DCCC
9	Ashwagosha Ganju	Former Director	SASE
10	Ayushi Biswas	Project Assistant	DCCC
11	Babu Govindha Raj K	Scientist	ISRO
12	Bala Nela	Research Scholar	IIT-Bombay
13	Bhanu Pratap	Project scientist	ESSO - NCPOR
14	Bisma Yousuf	CSIR-SRF	Wadia Institute of Himalayan Geology
15	Dhiren Shrestha	Director	DST, Sikkim
16	Dr. Ajanta Goswami	Assistant Professor	IIT-Roorkee
17	Dr. Akhilesh Gupta	Advisor	DST
18	Dr. Bhushan S Deota	Professor	The M.S University of Baroda, Vadodara
19	Dr. D.P. Dobhal	Scientist	Wadia Institute of Himalayan Geology, Dehra Dun
20	Dr. Gulab Singh	Associate Professor	IIT-Bombay
21	Dr. M. R Bhutiyani	Scientist	Defense Research and Development Organization
22	Dr. Parmanad Sharma	Scientist D	National Centre for Polar and Ocean research, Goa
23	Dr. Sanjay K Jain	Scientist G	National Institute of Hydrology, Roorkee
24	Dr. Sunil Dhar	Associate Professor	Central University of Jammu
25	Dr. Thamban Meloth	Scientist E	National Centre for Polar and Ocean research, Goa
26	Dr.Ajay Dashora	Assistant Professor	IIT-Guwahati
27	Dr. Raaj Ramsankaran	Associate Professor	IIT-Bombay
28	Gautami Samui	Project Scientist	NCPOR
29	Geetha Priya	Professor	CIIRC-Jyothy Institute of Technology
30	H.C. Nainwal	Professor	HNB Garhwal University, Srinagar
31	Harendra Singh Negi	Scientist	Snow and Avalanche Study Establishment, Chandigarh

32	Indira Bohra	Scientist	Wadia Institute of Himalayan Geology, Dehra dun
33	Indra Sekhar Sen	Assistant Professor	IIT-Kanpur
34	Irfan Rashid	Assistant Professor	University of Kashmir
35	Mansi Joshi	Project Assistant	DCCC
36	Mohammad Najim Nasimi	Lecturer	Kabul Polytechnic University
37	Mohd Azam	Assistant Professor	IIT Indore
38	Nagajothi Venkatesan	Research Student	Jyothy Institute of Technology
39	Nilendu Singh	Scientist	Centre for Glaciology
40	Pradeep S	PhD	DCCC
41	Pradeep Vashisht	PhD	The Energy Resources Institute, Delhi
42	Pratibha S	Project Scientist	DCCC
43	Prof. A L. Ramanathan	Professor	JNU, New Delhi
44	Prof. Argha Banerjee	Professor	Indian Institute of Science Education and Research, Pune
45	R.C Jain	Former Chairman	Central Ground water Board
46	Rajesh Kumar	Professor	Sharda University
47	Rakesh Ranjan	Assistant Professor	Sikkim University, Gangtok
48	Remya S N	SRF	DCCC
49	Rupal Budhbhatti	Project Associate	DCCC
50	S.S Randhawa	Scientific officer	State Centre for climate change, Shimla
51	Sayli Tawde	RA	Indian Institute of Science, Bengaluru
52	Shivika Aggrawal	Student	Indira Gandhi National Open University
53	Shresth Tayal	Fellow	The Energy and Resources Institute, Delhi
54	Shubha V	Student	Jyothi Institute of Technology
55	Sonia Grover	Associate fellow	The Energy Resources Institute, Delhi
56	Tajdarul Syed	Associate Professor	IIT(ISM)- Dhanbad
57	Tejal Shirsat	Project Assistant	DCCC
58	Ulfat Majeed	PhD Student	University of Kashmir
59	Veena Prasad	Project Assistant	DCCC
60	Vinay Gaddam	Associate Professor	Dhanekula Institute of Engg & Tech
61	Vishakha Pandey	M.Tech Student	IIT-Bombay

Program Agenda:

Technical session I - Science of Cryosphere		
Oral Presentations		
09.00-09.15	Inauguration	Prof. S. K. Satheesh
09.15-09.30	Mapping glacier velocity on Samudra Tapu using Sentinel-I D-InSAR data	Geetha Priya
09.30-09.45	Early 21st century surface mass balance estimates for glaciers in Chandra basin, Western Himalayas between 2000 and 2018	Anita Chandrasekharan
09.45-10.00	Snow water equivalent and snow depth estimation in the Himalayas	Akshay Patil
10.00-10.15	Mass Budget and Surface Velocity variations of Glaciers in Western Himalaya	Tajdarul Syed
10.15-10.30	Snow and Ice melt contributions in a highly glacierized catchment of Chhota Shigri Glacier (India) over the last five decades	Mohd Farooq Azam
10.30-10.45	Glacier mass balance estimation of Naradu Glacier, Western Himalaya	Rajesh Kumar
10.45-11.00	Crucial role of Spring shed management for springs Revival in Indian Himalayas	R C Jain
11.00-11.30	**Tea Break**	
Technical session II - Water Security and Policy (15 minutes each)		
11:30-11:45	Himalayan Cryosphere Sustenance: Issues, Challenges and Opportunities	Ashwagosha Ganju
11:45-12:00	Inventory of Glacial Lakes and its Evolution in Uttarakhand Himalaya Using Time Series Satellite Data	Babu Govindh Raj K
12:00-12:15	HIGTHIM - An automated tool for modelling potential glacier lakes	Pradeep S
12:15-12:30	Climate Change impacts on Himalayan Glaciers and implications on energy security of the country	Shresth Tayal
12:30-12:45	Development of Cryospheric Services for Management of Hydropower Utilities in the Himalayan region	Nilendu Singh
12:45-13:00	Ice mass loss in Central Himalaya since 1960s is unprecedented in last three centuries	Ayushi Biswas
13.00-14.00	Lunch Break	
14.00-14.15	Recent changes in glaciers and climate of Shyok basin, East-Karakoram	Harendra Singh Negi
14.15-14.30	Future glacier water availability in Satluj and Beas basins for twenty-first century	Veena Prasad
14.30-15.00	**Poster Presentation (2 minutes)**	
Technical session III - Panel discussion on "How to reorganize glaciological research in India?"		
16.00-16.30	**Tea Break**	
16.30-17.30	**Poster Session**	
17.30-18.00	**Concluding Session**	
19.00-21.30	**Dinner at IISc main guest house**	

Fig 15: Participants at the special session conference on Cryosphere and Water Security.

Fig 16: Dr. M Mani delivering lecture.

Fig 17: Dr. H S Negi delivering lecture.

Fig 18: Dr. R C Jain delivering lecture.

Poster Session

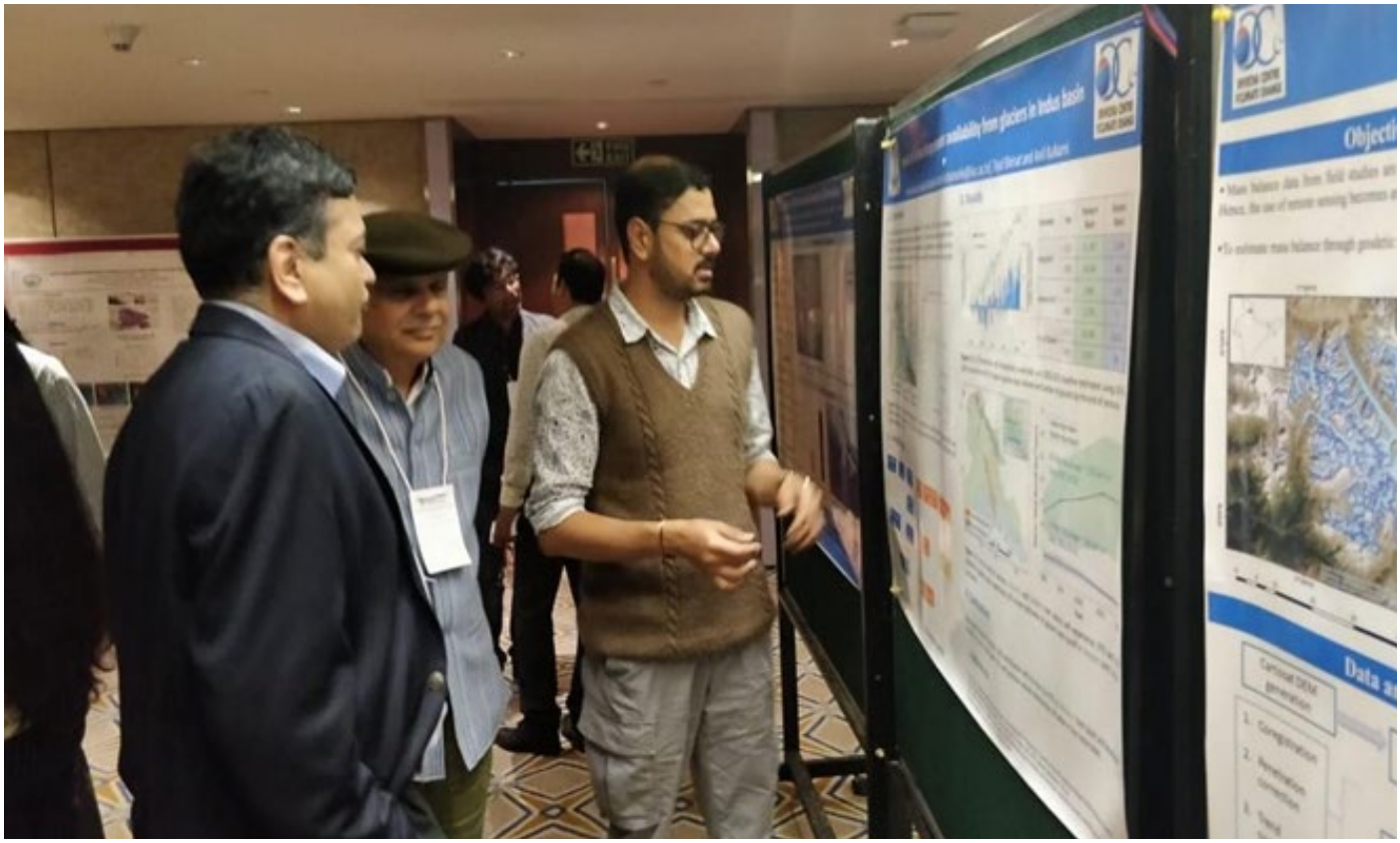

Fig 19: Poster session in progress.

Panel Discussion

Fig 20: Pannel discussion in progress.

4. Report by Consortium for DEWATS Dissemination (CDD) Society

Consortium for DEWATS Dissemination Society

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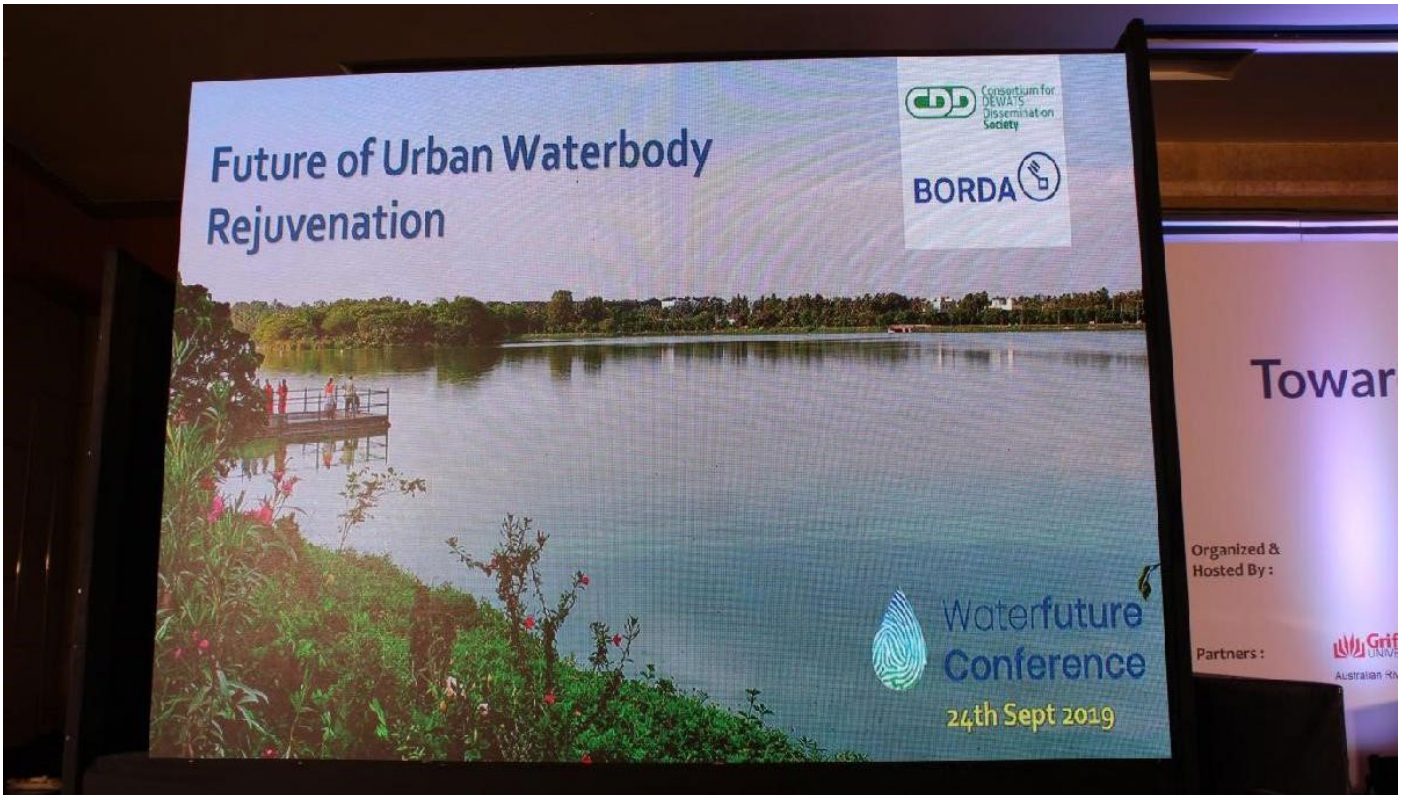
Future of Urban Waterbody RejuvenationWater Future Conference

24 September 2019, Hotel Sheraton Grand, Bengaluru



About the session:

Consortium of DEWATS Dissemination (CDD) Society conducted a special session on 'Future of Urban Waterbody Rejuvenation' at the Water Future Conference, Hotel Sheraton Grand, Bengaluru on 24th September 2019 from 16:00 – 19:00. The international conference was organized by Future Earth in collaboration with Divecha Centre for Climate Change, Indian Institute of Science, Bengaluru, India. Representatives from government departments, scientific and academic institutes, lake activists, citizen groups, civil society organizations, corporate entities and community representatives participated in the event.

Background:

Waterbodies have lost their self-healing capacities due to unplanned urbanisation and industrialisation. Historically, waterbodies were the primary source of water supply for towns and were conserved in pristine health. With increased dependency of cities/ towns on piped water supply as well as unregulated exploitation of groundwater, waterbodies have been ignored and have become disposal sites for polluted water and solid waste. It is widely known and acknowledged that water scarcity is growing and therefore reviving waterbodies has become an inevitable option. Hence, increased attention is being given by the government, policy makers and sector professionals to rejuvenate waterbodies. Waterbody rejuvenation also aligns with Sustainable Development Goals (SDGs) 3, 6 and 11 to achieve the larger objective of urban water security. As polluted waterbodies are an indicator of an unhealthy urban environment, the government has decided to undertake a rejuvenation exercise of urban waterbodies across India, on a mission mode, through its Jal Shakti Abhiyan. It is therefore pertinent to discuss and debate existing ways and means to rejuvenate waterbodies, the associated gaps and way forward to achieve a holistic and sustainable solution to waterbody rejuvenation.

This session is aimed to bringing experts from different fields to discuss and understand future perspectives of urban waterbody rejuvenation and provide a platform for dialogue amongst various stakeholders involved. The stakeholders included government departments, scientific and academic institutes, lake activists, citizen groups, civil society organizations, corporate entities and community representatives. The programme serves as a platform for experts, users and policy makers to share their understanding and perspectives regarding waterbody rejuvenation. The speakers were encouraged to share their experience on the current issues plaguing waterbodies, existing processes and systems for their rejuvenation in India, challenges in carrying out waterbody rejuvenation interventions, government initiatives, funding patterns in the sector, and success stories.

Opening remarks – Mr Ganapathy PG, Director of Programs, CDD Society

Waterbodies have lost their importance in the rapid urbanization that has taken place in past three-four decades. Historically, waterbodies were carriers

of stormwater and people preserved the natural ecosystem as a symbol of nature's gift. Over time, domestic and industrial sewage entered these waterbodies; more recently, huge quantum of solid waste are polluting waterbodies, which has become an eyesore. There is a need to create an enabling framework to revive and restore waterbodies by addressing the concerns of all stakeholders in a holistic manner.

This session is aimed at:

- Exploring ways to reconnect waterbodies to citizens

- Un-packing the Jal Shakti Ministry guidelines to rejuvenate urban waterbodies

- Highlighting funding patterns for rejuvenation of waterbodies – capital assets and Operations and Maintenance

Panel Discussion on Future of Urban Waterbody Rejuvenation

Panellists:

1. Mr Vishwanath S, Trustee, Biome Environmental Solutions

2. Dr Veena Srinivasan, Fellow, ATREE

3. Dr Suresh Rohilla, Sr Director, Centre for Science and Environment

4. Ms Latharaman Jaigopal, Co-Founder, Inspiration and President, CDD Society

Moderator: Ms Sonal Pareek Kaushik, Consultant, CDD Society

Discussions:

Dr Suresh Rohilla: Waterbody rejuvenation is now picking up pace with policy and decision makers realising their importance. Storm drains that were supposed to carry storm water during high rainfall events have now been reduced to wastewater channels due to a high degree of encroachments along their catchments and unregulated discharge of domestic sewage into streams. The Jal Shakti Abhiyan is yet to define an enabling framework that can facilitate a dialogue amongst different stakeholders. Intent is good. However, the long-term engagement strategy needs to be defined. For example, Desilting of waterbodies may be visualized differently by environmentalists and a water expert.

Dr Veena Srinivasan: The Rejuvenation of waterbodies can be looked at from two angles. Constructed (impermeable infrastructure such as concrete lining, silt control structures etc.) versus nature-based infrastructure (wetlands, bunds, bioswales etc.). Each has its own purpose. Different stakeholders would see the waterbody rejuvenation differently. What is the end purpose of rejuvenation? A Lake vision document can be one approach to garner a shared understanding for waterbody rejuvenation.

Ms Latha Raman Jaigopal: Solid waste management for canal rejuvenation is a persisting challenge. Liquid waste management is still manageable as largely domestic sewage enters these channels. Citing the example of Alapphuza town in Kerala (Venice of India), the canal network was a major source of navigation, trading and allied purposes but now it has become a site for dumping solid waste and sewage.

Mr Vishwanath S: In order to revive Jakkur Lake, Rs. 100 crores worth of investments were made. Out of which, almost 80% went for wastewater treatment systems and the remaining 20% went for creating bio-parks, walkways and other recreational infrastructure. Despite all this, around 9 MLD (Million Litres per day) of wastewater enters the lake. Lake water management planning is the need of the hour. Silt from lakebed can be used by farmers but if the silt is toxic, it would create more harm than benefits. What purpose is water required for – that needs to be made clear.

He made a comparison between Singapore and Bengaluru. Singapore's population is 2.5 times that of Bengaluru but the capital infrastructure spending in Bengaluru is 20% that of Singapore. Close to 40% of the public exchequers' money escapes as leakages in Bengaluru. It therefore requires patrons to look at all forms of water together (an Integrated Urban Water Management approach) viz. Surface water, rainwater, ground water and treated water.

In order to give justice to waterbody rejuvenation, the government requires: a) Capacitated staff, b) Adequate financial outlay and c) Accountability towards the works. It is better to convert all waterbodies to wetlands as they are easy and cost effective to manage as compared to acres of waterbody along with recreational infrastructure.

Dr Veena Srinivasan: With respect to water quality of lake water, instead of brining water to meet domestic needs from distant sources (as almost all metro cities in India depend on distant water sources for their domestic supply) it is better to utilise lake water for non-potable purposes such as flushing, irrigation etc.

Dr Suresh Rohilla: On the question of governance, the waterbody and its catchment are governed separately. While the catchment is governed with land-use planning department, the waterbody is managed by the PHE or similar such authority of the ULB. With rapid urbanization, the value for water has diminished and therefore it is required to map the entire watershed in order to approach the rejuvenation more holistically.

The correct approach can be to implement water sensitive urban design principles to any land use planning.

Ms Latha Raman Jaigopal: In the context of storm drains, such channels reduce the complexities (in form of solid wastes and sewage) that may enter the waterbody. Therefore, cleaning these channels ensures, to a certain degree, a clean and thriving waterbody.

Mr Vishwanath S: On the question of funding, the cost of rejuvenating a waterbody is much more than managing a wetland. Developed countries cleaned their waterbodies only once their economy developed. The Jal Shakti Abhiyan has noble goals but funding patterns are not clearly defined.

Dr Suresh Rohilla: The role of a waterbody as a flood mitigation structure cannot be neglected as waterbodies absorb excess storm water from their catchment during high rainfall events. Also, subsurface water systems are much more complex and the role that waterbodies play in maintaining these systems cannot be ignored. Waterbodies essentially helps in a) groundwater

recharge and b) flood mitigation.

Dr Veena Srinivasan: With respect to waterbody as flood mitigation structures, if for most times the waterbody is filled with water, how would it accommodate the excess storm water during high rainfall events? The purpose of flood mitigation in such cases would remain unsolved and may result in flooding despite the waterbody.

All panellists were of the common opinion that innovative financial and institutional incentives need to be implemented as that would strengthen the utilities and also incentivise citizens. Most utilities in India are not able to recover the cost of supplying water to households even if the water supply tariff exists. There is no tariff for wastewater collection or sewer connection. Therefore, the value of water is not realised by citizens.

With respect to question on capacity of officials of Jal Shakti Ministry, they all opined it is too early to comment. But all believed that there should be one democratic institution that would manage all the waters of a concerned ULB.

At the end of the panel discussions, the participants posed the following questions/concerns to the panellists;

1. How to effectively ensure participation of citizens and take up projects driven by citizen groups?

2. Why is the government still in preliminary stage of discussion with respect to waterbody rejuvenation?

3. Lakes/waterbodies are structures for flood mitigation, trade-off between aesthetics v/s hydraulic function, what is the modus operandi?

4. Why no vegetation in storm water drains? Can it help abate pollution load?

5. What is the present way out to manage water effectively? Improved groundwater management techniques, their scope?

6. What about the people dependent on livelihood around the lakes? How to accommodate their concerns?

7. What is the simplest way to build capacities of the junior staff involved with managing waterbody rejuvenation projects?

8. What role can youth play in bringing about change in the waterbody rejuvenation space?

The panellists answered some of the concerns; while others were discussed as many solutions are complex rather than simple, hence merit a discussion.

Expert Presentation 1:
Restoration of Urban Blue Acres,
Ms Sahana Goswami, Manager Water and Cities Program, World Resource Institute India

She talked about WRI's approach towards waterbody rejuvenation and explained their 5 theories of rejuvenation.

Theory 1: Join the dots and understand the developmental changes that have taken place in the lake watershed.
Theory 2: A waterbody is as clean as its

catchment.
Theory 3: No water is bad water
Theory 4: Planning for the big picture
Theory 5: Ambition for vibrant living water

Finally, she spoke on the recipe for disaster - misplaced priorities for investment.

Expert Presentation 2: Alapphuza Canal Rejuvenation, Ms Latha Raman Jaigopal, Co-founder Inspiration and President, CDD Society

She spoke about the Alapphuza canal rejuvenation works that highlighted the efforts undertaken and how key stakeholders joined together to make the project a success. Driven by the Finance Minister of Kerala, the historical town with its intertwining canal networks is under-progress of revival in collaboration with the community and supporting institutions.

Concluding remarks:

Mr Andrews Jacob from CDD Society concluded the session and shared two key objectives attained;

1) Unpacking the Jal Shakti Guidelines for urban waterbody rejuvenation and 2) Facilitating a new network partners' meet.

Outcomes:

The session helped to understand the current issues plaguing waterbodies, existing processes and systems for their rejuvenation in India, challenges in carrying out waterbody rejuvenation interventions, government initiatives and funding patterns in the sector. The success stories gave the audience hope! The session also helped build a network of people, organizations and institutions working in the water space.

Fig 21: Session on 'Future of Urban Waterbody Rejuvenation' in progress.

Program Agenda:

Time	Description
16:00 – 16:30	**Welcome note** - Introduction to the session - Objectives of the session Presenter: Ganapathy PG & Mr Andrews Jacob, CDD Society
16:30 – 17:40	**Panel discussion on Future of Urban Water Bodies Rejuvenation in the context of Jal Shakthi Abhiyan** Panel discussion (10 minutes by Moderator+40 minutes for panel discussion+20 min for Q & A) **Panel Members:** Mr S Vishwanath, Biome Environmental Solutions Dr Suresh Rohilla, Academic Director, Centre for Science & Environment Dr Veena Srinivasan, ATREE Ms Latharaman, Director, Inspiration & President, CDD Society **Moderator:** Ms Sonal Pareek, Consultant, CDD Society
17:40 – 18:40	**Expert talk – Sharing of experiences and case studies (15 mins presentation by experts followed by 5 mins Q&A)** *The experts would share their experience with waterbody rejuvenation through case studies and highlight the adopted approach as well as challenges encountered towards WBR.* 1. Ms Sahana Goswami, WRI – Restoration of Urban blue acres 2. Ms Latharaman, Inspiration – Alappuzha Canal Rejuvenation
18:40 – 18:50	Concluding remarks

Photo Gallery

Fig 22: Discussions on ‘Future of Urban Waterbody Rejuvenation’ in progress.


Waterfuture
Conference
Towards a Sustainable Water Future
24 - 27 September 2019
Bengaluru, India

Climate Change and Water Management at Water Future Conference

27 September 2019, JN Tata Room A,

Indian Institute of Science, Bengaluru

About the session:

Climate change across the globe has been affecting water availability through altered rainfall pattern and increased frequency of droughts. With high population density and low resilience capacity, all developing and under-developed countries are at risk of water security. Thus, water security is a big concern for rural and urban areas as urban water supply depends mainly on water from nearby dams or rivers, while agriculture is the main water – intensive activity in rural areas. Climate smart innovations in agriculture with optimal cropping pattern and weather-based irrigation can be practised. Water conservation and its efficient utilisation requires water auditing, waterproof utilities, water quality assessment, wastewater treatment, wastewater recycling and reuse. Moreover, the equity in water distribution is another major concern that involves multiple dimensions including gender, youth, user communities and the like. Hence, a strong water governance structure is also a mandate in order to ensure accountability and transparency in water allocation and distribution.

The session brought together

- The academia and young practitioners to address climate change and water challenges at different levels from a multi stakeholder perspective
- It aimed to highlight the need for incorporating SDG 6 in any action plan for addressing challenges of climate change through participatory approach

Academia speakers included,
Ranjana Ray Chaudhuri, TERI School of Advanced Studies
Kamna Sachdeva, Associate Professor, TERI School of Advanced Studies
Sherly M A, Assistant Professor, TERI School of Advanced Studies
Akash Sondhi, Assistant Professor, TERI School of Advanced Studies

The above-mentioned speakers gave a talk on:

1) Water cooperation for climate resilience: path to achieve water security and avoiding conflicts;
2) Assessing climate smart urban water availability, accessibility, affordability and well-being;
3) Sustainable water perspectives in the context of Disaster Risk and Climate Resilience; and
4) Experience of working in the field of climate change and water management at grass root level.

The audience appreciated the applied research approach of TERI SCHOOL OF ADVANCED STUDIES.

Fig 23: One of the participant presenting in the session on 'Climate Change and Water Management at Water Future Conference'.

X. Session Summaries (As reported by Rapporteurs)

1. Assessing Sustainability in Water Space

SK Jain

We need to assess water resources in space and time, keep on assessing these resources for the sake of sustainable development. Assess demands put on water, the matches and mismatches on road to sustainable development.

Rajeev Mahajan: "Tomorrow's climate crisis is going to be a water crisis."

In all the Climate Change scenarios, there will be a global scale problem of water security. Monitoring and judicious planning of water use along with quality observations and timely forecasting ability of factors influencing water is the need of the hour. This can be done by developing and maintaining of Global Framework of Climate Services (GFCS) under the guidelines of the World Meteorological Organisation. GFCS goals are on Global, National and Regional levels. National scenarios of implementation of GFCS :- Observation & Monitoring, Research monitoring & Prediction, and Climate Services Information System have been implemented reasonably well by National Meteorological and Hydrological Services (NMHS). User Interface Platform not developed. Great strides in Agriculture & Food Security and Disaster Risk Management. No such progress in Water services. Health and Energy are yet to be taken care of by either Indian Meteorological Department (IMD) or National Hydrological Services (NHS). Regional GFCS are presently implemented by IMD (south west summer monsoon prediction) , IITM and RCC being developed under WMO initiative. National implementation needs to be stepped up because IMD etc are national repositories of meteorological data required for climate/weather services and also they have capacity to transform useful information into usable information. Convening the convergence of the efforts of all stakeholders with water at core of adaptation strategies.

Chandan Banerjee: Assessment of surface water storage trends for increasing groundwater areas in India

Nasa's GRACE mission enabled scientists to estimate and assess groundwater, earlier it was through well observations. Decreasing trend of groundwater in Northern India whereas an increasing trend is observed in Southern part of India (possible response to 2002 drought). Rainfall is an important factor for the groundwater recharge.

Ashlin Alexander: Assessment of multiple modelling approaches to address the quest for physically realistic hydrologic models

Severe flood to drought conditions in many parts of India. Dried up reservoirs. Proper monitoring and management of water resources. Hydrological modelling is a solution. A good model should have proper representation of dominant processes in respective catchments. Develop a focused place-based model under a robust and flexible framework rather than using a prior model and fitting it to the catchment under study.

Saumya Srivastava: Multi-site and multi-variate hydrological model calibration for spatially heterogenous catchments

Spatial variability of model parameters for large basins should be undertaken for realistic basin modelling. The huge size of the basin requires considerable calibration effort and computation time. These can be optimized by using a layered parallelized calibration using high performance computing.

2. Geogenic Pollutants in Groundwater

Dr. Prasanna V Sampath: Groundwater assessment at local scales: Case study of India

This study talked about the groundwater consumption at local scale. The requirement of doing local scale study is because the source of majority of the groundwater related problem can be traced back to the vulnerability of local scale parameters. The challenges of local scale study are the lack of multi-scale data. The objective of the present study is to estimate ground water consumption mainly for agriculture purpose. This study picked up 5 top cultivated crops in different areas of Andhra Pradesh and calculated the Gross vulnerability Index of those area in order to identify the hot spot of groundwater vulnerability. Calculation were done based on the summation of groundwater consumption and power consumption which in turn depends on the parameter of rainfall amount. If the amount of rainfall in a particular area is not sufficient for a particular type of crop cultivation requirement, there comes the use of water by groundwater consumption which causes large draw-down. Therefore, the policy implications of the present study are that, identifying the hot spot of vulnerability in terms of groundwater consumption and power consumption is a new scientific technique to plan crop cultivation diversity. It optimizes water and power consumptions and identifies the hotspot of groundwater consumption.

Javier Castro: The flow system approach for coping

with changing groundwater scenarios

This study is describing the importance of characterising intermediate flow dynamics in the aquifer, and sub-surface geology of the study area in order to identify the severity of the groundwater contamination problem occurred in that area. He presented a case study in Mexico (Mexican Altiplano) in terms of Fluoride contamination problem in groundwater. It was explained that, how Fluoride concentration in ground water was released from the sub-surface volcanic rocks and basin fill materials which are composed of Fluoride minerals. It was indicated that the development of Fluoride problem in the groundwater has been increased from past time due to the practise of increasing extraction and deepening of groundwater. He showed Li as the tracer of different Fluoride contaminated water types in the aquifer and tied it up with their corresponding groundwater flow conditions. He defined hydrological condition (conductivity) of different Fluoride contaminated water types and showed how the intermediate groundwater flow pattern is driving the fluctuation in the contamination problem. He suggested a new scientific geochemical approach in the removal of Fluoride concentration from the groundwater in terms of addition of Ca into the aquifer system and decreasing groundwater temperature which forms Calcium Fluoride and removes Fluoride concentration from the groundwater. Therefore, it is important to characterise groundwater condition and groundwater flow system in order to get rid of groundwater related problems.

Dr. Mona Dahabiah

Due to large consumption of groundwater, groundwater level in a well suffers large draw-down and becomes dry. However, it is difficult to trace back what are wells will be dried soon or suffering from huge draw-down (by the change in pump setting) and where to drill the well for water supply. There comes the importance of groundwater flow modelling and estimation/prediction of the draw-down effect in wells for future. She described nicely here how to do groundwater flow modelling for a particular area. Groundwater level data, geological data, hydrological data, hydraulic data were used for building up the conceptual model and then from that the numerical model has been carried out. After that the numerical model is calibrated in steady-state/transit state in order to check the best fit between the calculated data (model data) and observed data and to understand the groundwater flow directions according to the conceptual understandings which are the major challenges defined during the present talk. For the area Gordon (poor water country) using groundwater flow numerical modelling, she got nice fitting between the calculated (model data) and observed data up to the year of 2000, however after 2000 there was a sudden draw-down. Here comes the importance of remote sensing study in this case for a particular area, which she explained as a new scientific approach to face the challenges. After using remote sensing survey, there was a huge improvement between the observed data and the model data. Predicting/estimating the ground water draw-down problem will help to improve the energy cost as well as it will spread the awareness in the common people so that they can plan

their water usage for the agriculture purpose accordingly. It was suggested that recharge scenario of the groundwater system has been poorly monitored and poorly modelled till now which can be a good idea to work on in future to solve the groundwater related problems.

Asrarul Jeelani

Water resources and social structure in Arsenic contaminated village in Patna district. This talk was about the social survey of arsenic contamination in the dug well and hand pumps between people belongs to different caste community. People of different caste from the same village consume water from different wells. This study presented a sociological report on the arsenic concentration in the wells belong to each caste community in different villages as well as it documented the several health issues due to the consumption of As-contaminated water and the personal interview reports of the arsenic affected patients in the villages.

Mr. Sinha Ray

He gave a brief idea about the present status of Arsenic and Fluoride contamination in the groundwater of West Bengal. 12 of surface water based PWS system and 338 of groundwater based PWS schemes are available in that area. To assess the efficiency of the removal technology and to address the gaps in monitory operation and maintenance, several renowned institutions have been engaged. The plants should be monitored properly so that it cannot be contaminated for the people to use. Also, the sludge management should be taken care seriously, the media coming out from the sludge should not be disposed randomly. It should be dumped in a certain place so that it can't be a secondary source of contamination. He also gave brief idea about how the bio-remediation items have been used to reduce the As level in the sludge media.

Dr. Debashish Chatterjee

Arsenic in shallow Bengal aquifer: Large scale human-water interaction and suffering. He gave a brief idea about the different mechanisms of As mobilization in the groundwater. This study provides a good scientific idea about the generation of redox condition in the groundwater in a relation to the groundwater level draw down effect and anthropogenic input (wastewater impact) by showing case studies at Nadia district, West Bengal, India. He showed a combined geo-chemical study about the several controlling factors driving As level fluctuation in the groundwater both spatially (geological occurrence of high and low As water) and temporally.

Dr. S. A. Pandit

Geological causes for high Uranium content in groundwater of some parts of India are not well understood as yet. The geological setting in which such waters occur in Punjab, Haryana, Rajasthan, Gujrat, Andhra, Telangana, Karnataka and Tamil Nadu are discussed in this presentation. As per the speaker there are no industries or nuclear facilities contributing to Uranium contamination in the groundwater of the various regions examined in this work. Secondary contributions through agricultural activity or fly ash emissions from thermal power plants have been examined by

earlier researchers and found that their contribution to Uranium is negligible. Therefore, it is imperative to understand the geological environment in which the Uranium rich groundwater occurs in the hard and soft rock areas of the country where it is widely distributed. Establishing the actual cause can pave way for evolving mitigation measures. It is important for the large population which is directly dependent on groundwater for drinking, domestic consumption and irrigation purposes. It helps the local and central government departments for implementing proper methods of treatment and public water supply.

Dr. R. Srinivasan

Processing of IMIS data base of > 300000 analyses of groundwaters of Karnataka has provide basis for generation of maps showing high (>1.5mg/l), very high (>3mg/l) and abnormally high (>5mg/l) fluoride ground zones in Karnataka. The districts in which samples with more than 3mg/l of fluoride were found to be frequent are Gulbarga, Yadgir, Bagalkot, Raichur, Koppal, and Bellary in Northern Karnataka; Tumkur, Kolar, Chikkaballapur in Southern Karnataka. A holistic approach consisting of delineation of high fluoride ground water areas, their geological setting, petromineralographic study of the aquifer rocks, geochemistry of the aquifers, water-rock interaction modelling, development of sustainable technologies, medical and nutritional intervention for reversing fluorosis, are required for solving the problem of fluorosis.

Mr. Pasan

The aims of his study were to assess the drinking water quality, drinking behaviour and commonly use water sources among CKDu (Chronic Kidney Disease: gradual loss of kidney function over time) patients in Wilgamuwa, Sri Lanka. CKDu is one of the severe problems in Sri Lanka. Present report is based on a case study on 302 CKDu patients in Wilgamuwa, Sri Lanka where water samples were collected from each individual's water source and then measured the water hardness on site as well as in laboratory. From the survey it was observed that Male population was more severely affected by CKDu as compared to Female population. The analytical results showed high hardness values above threshold levels for human consumption according to WHO guidelines. As a conclusion of this study it can be said that environmental factors such as higher levels of hardness in drinking water likely to be a factor for the disease CKDu in human health.

3. Water-Energy-Food Nexus Assessment and Governance

Presenters: Martina Floerke (Ruhr-University Bochum), Declan Conway (Grantham Research Institute), Jamie Pittock (Australian National University), Richard G. Lawford (Morgan State University)

The chair, **Prof. Rabi H. Mohtar** opened the session with a discussion about the journey of the Nexus from conceptual to more analytical framework and highlighted the need for moving forward to have success stories. This session goal was to share nexus research related to assessment and governance.

The first presentation by Dr Martina Floerke investigates the possibility of using the water quality (salinity in this case) to assess the WEF interlinkages. Dr Declan Conway highlighted the need to address climate risks (El- Nino) to hydropower in Africa. He highlighted the draught related decrease in electricity production in Zambia which in-turn affected food security and small businesses. Dr Jamie Pittock and Dr Richard G. Lawford discussed governance-related issues in the perspective of sustainable irrigation in Africa and integrated information systems. The scale of the challenges can vary from the individual level to the national level and world level (SDGs).

It was demonstrated that the model-based studies can link the water quality to the WEF resources. It was also highlighted that the WEF nexus is all about trade-offs and interlinkages between different SDG goals were discussed. The session advocated different strategies to Transform trade-offs into synergies. The requirement of integrated analysis in the WEF nexus domain was also mentioned. One of the presenters, Dr Declan Conway urged to strengthen water-energy coordination.

Dr Jamie Pittock discussed that Simple tools may help farmers apply less water and increase yields. Innovation platforms enhanced value chains are very important to sustain these types of reforms. He also mentioned that fixing simple issues empowered farmers to improve their relationships with different government institutions.

Dr Richard Lawford discussed the ways of achieving sustainability in the Water-Energy-Food Nexus through integrated information, better governance and collaboration. Water, energy and food resources and security depends on various factors that are highly interrelated. Thus, WEF Nexus analysis and governance requires a systematic data and information platform which can be easily accessed and shared at the cross-sector level. This can be achieved through user surveys and consultation where users can define their specific WEF data needs. Further, giving scientific support to this platform, analysis of existing platforms, development of an inventory of data and tools will help strengthen the WEF Nexus platform.

Mohammad Alhayari: Groundwater resources assessment in Jordan

• Jordan is a middle-income economy, population 10.4 million (1.5-2 million in 1952-
53), semi-arid, principle supply is groundwater.
• Assessment of the A7B2 Aquifer sampling during rainy and summer season.
• GW shows significant changes in flow patterns and dramatic decline in 20 years, mandating changes in groundwater resource management and reallocation. Decline of over 100 meters.
• The last GW Assessment was in 1995. This study does a comprehensive coverage and compares results with the 1995 assessment.
• Comprehensive field campaign used differential gps with topographic survey to measure levels with unprecedented precision in 2017.
• No comprehensive hydrological assessment available in Jordan till now. Generates a trend analysis; the results of which are relevant for decision makers. The study provides a sound scientific base for the political discussion on reallocation or exploitation of alternative resources.
• Recommendation: assess illegal abstraction; public awareness; save water; and most critically identify and reform subsidies.

Interactions:

• Q: Chair: What are GW Abstractions?
A: Wells/Springs (possible to mean entirety of access to aquifer)
Q: What is the design of public awareness?
A: Through Religious Figures, Schools, Specific(ally) target(ing) to farmers who are at the forefront.
Q: Shakeel Ahmed: You have shown the GW flow reversal from NW to SE in 1995 to SE to NW in 2018 due to various obstructions, is this permanent?
A: Without multiple obstructions, refugee camps, buildings and unplanned growth
Q:S.A. Better Planning required?
A: Rehabilitation and recovery is not a realistic possibility especially with refugee camps.
Q: Any creative ways for public engagement?
• A: All recommendations are to remove obstructions, which is not realistically possible.

Sangeeta Mishra, Kavitha Ramkumar: Fractal analysis of water quality time series data by Hurst exponent and confirmation of its instability by estimating largest Lyapunov exponent

• Characteristic effect of water quality data addressed as memory effect and instability – randomness, persistency and anti-persistency of WQD evaluated by Hurst exponent. Instability (chaos) calculated by largest Lyapunov exponent.
• Concentrations of water (borewell samples) cross districts of Karnataka. Quality data of 66 villages. - fluorosis rate sampling above 5. 1.5 to 3-5 was found.

• Skeletal fluorosis, dental fluorosis tracked for young children and adults.
• Samples drawn extensive. Calcium carbonate and kidney stones/medical conditions tracked.
• DATA: 8 years data. 2010-2018.
• First 2 years, 2010-11 and 2011-12, high fluoride. Stopped drinking ground water. Tracking high fluoride.
• Less data in 2012-2018. large data in 2010-2012.
• Bagalkot, Chikkaballapur, Koppal, Tumkur. High Fluoride. Affected by dental fluorosis. Moderate to severe.
• UNICEF tests for skeletal fluorosis used to map.
• 30 villages in first field work. Majority of samples show above 1.5.
• Fluoride is a geogenic contaminant, geological map shows high and unsafe contamination. Granite and granitic areas, eastern part of Karnataka, semi-arid climate.
• IMIS Data used and extrapolated.
• Real photos shown. Of dental and skeletal fluorosis.
• Water quality time series data, concentrations indicators such as fluoride, manganese, sulphate, total hardness, TDS, iron and pH, are calculated from 2010-2018.
• Rock samples, borewell powders, phosphatic fertilizers used.
• On WQS: Sangeeta Mishra Continues
• Chaotic nature of water data.
• Several weighted indicators, numerical nature of water quality.
• Benefits to detect a trend which will further help to distribute a statistical distribution for further attaching a model to assess/forecast water quality directly benefiting decision makers.
• Fractal scaling : false inference on statistical significance of trends.
• Traditional methods are calculated in the form of spectral scaling.
• Behaviour of water quality.
• Awareness of quality of data
• Computed water quality index
• Hurst exponent estimation: 2010 – 2018
• 6 metrics: Fl, No3, pH, TDS, TH, Fe.
• H = 0.5 Random walk, greater than 0.5: short term memory.
• Linear Method, Non-Linear Methods available
• Parameter : how to calculate the WQI/SI
• Degradation in water quality in the year wise analysis done.
•Conclusion: this technique recommended to compute a water quality index and determine the predictive model for forecasting water quality index.

Interactions:

Q: Of 6 parameters taken into account, one parameter and changes in the parameter will affect WQI
A: Chair: Relative weight will nullify changes in WQI.
Q: How to link this with quality index?
A: Short-term memory
Q: Hot spot linkage?
A: Is sampling is regular/irregular, data diffusion exists or not? Fractal method is exact to identify hot spots linkages.
Q: Direct sampling to cross check data?
A: Data collected from multiple sampling and ranges and sources.
Q: Skeletal fluorosis only elderly? Because contradictory data exists in other sites.
A: Not tracked in children, outcome mentioned through observations. Children newly exposed do not show signs of skeletal fluorosis. Wrong notion but not established fact. Government data can be faulty and Misrepresented. Selective record method.

Virendra Tiwari: A Multi Layered aquifers groundwater model for leakage assessment of arsenic contamination threat in a part of the ganga basin

• Assessment of arsenic contamination between variations of 2 aquifers, I and II.
• Arsenic in ganga basin: geogenic : transportation of arsenic through the sediments through Himalayan silt and deposited. Concentration however through exploitation of groundwater, overuse of fertilisers, burning of coal, leeching of metals from coal ash tailings.
• WHO SAFE limit for As is 10ug/L
• Overview of As release in groundwater
• Vadose zone (unsaturated)
• Phreatic zone (saturated) – Aerobic organisms consume O2. Anaerobic microbes reduce FeOOH > release as Fe and As.
• Schematic model for possible hydrodynamics
• Assessing groundwater flow dynamics among two-tiered aquifers.
• Pumping vs recharge.
• Projection: System response to different extraction scenarios.
• Water Balance: Inflow-Outflow/Change in Storage.
• Study Area: Ganga River Northern Boundary
• 1,102 SqKM, 40- 50 m, Avg Rainfall 960mm/year.
• Arsenic in Handpump: 724ppb in Naikatola; 538 at Kala Diara villages in Maner Block.
• Model Grid Design: Aquifer Mapping Validated through 3 methodologies (electromatic observations validated from borewell information – hydraulic conductivity – pumpage- hydrological properties in simulation of hydraulic movements.
• Assigned Recharge : recharge values tracked and draft assignments to multi-aquifers.
• Flow model simulations:
• Steady Model (2012) - Transient Model (June 2012 – Dec 2017 – for calibration) :
• 6 scenarios used:
• As leakages ranging from 500 ppb / vulnerable As-contamination. To make the prediction at the Village Level!
• Land-holding level : Diara Village at Maner Taluka : Scenario generation from 2010-2022.

Summary:

• If we increase draft more than 20% from aquifer to semi confined aquifer it would lead to hydraulic heads and possible mixing/leakages. Reversal leakage can happen throughout the ganga basin.
• Decision making for less contaminated sustainable water future. Geogenic contamination present in the aquifer system, because of pumping at higher rate as a discussion of anthropogenic pumping influences. GW level for drinking as well as for agricultural purposes.
• Contaminants moving in the food chain systems.
• 90% use of GW is agriculture - there is a need for a precise delineation of the aquifer system and scenarios, approaches together to make a prediction for the future.

Dharani Saikia: Assessment of water quality at fluoride affected village Dikharomukh of Hojai district of Assam

• Causes of fluoride and how to mitigate

the problem the primary concern of the study.
• 165 households: 2010-2018.
• Aims: provide fluoride free water: identify gaps: to identify low cost, acceptable and sustainable solution.
• Dikharomukh is an identified fluoride endemic area. Govt of Assam undertaken a fluoride free pipe water supply system (PWSS), however fluorosis persists, study identifies the gaps in the present water sources.
• Participatory Rural Appraisal.
• household survey – to identify water sources, and the gaps in contamination.
• 165 households mapped – 23% ring bore well, 32% tube well, 42% both tube well and PWSS.
• Children suffering from skeletal fluorosis. 55 students below 5.
• PWSS:
• At Fluoride affected area : water scarcity at fluoride free areas: available water.
• UNICEF (2003- 18 units) Public health engineering department identified / water not tested.
• More than 1000 people crippled. After 2003. mostly affected children.
• PRA Activity: environment conservation centre identified fluoride at a UNICEF well.
• 2013: PWSS Dikharomukh scheme. Provided fluoride free water.
• Shallow dam catchment, consumer distance is 10km. No regular treatment.
• sustainable solution: PRA Activity: matrix ranking
• First preference dug well from
• Avoid tube well due to over fluoride
• Awareness

Interactions:

Q: one solution is rainwater : collection and supply. 2000 villages supplied with collected rainwater. It is a good solution.
A: Assam is a land of rivers and water sources. Water is easily available, 10ft of available water.
Q: Views of locals identified. Dug well safety identified. Contamination in dug well from microbial is very high so disinfectant.
A: Recommends source filtration and chlorination.
Q: Even bacteria, in boiling water not all removed.
A: Microbiological contamination is higher much higher at many areas. Survival of bacteria at high temperature is removed. But cooled water can be infected.

Debabrata Datta: A Machine Learning Approach to compute water quality index with uncertainty

• Government enforcing the development of AI in all fields. In this spirit, looking at water issues through AI.
• Current approach of water quality monitoring.
• Machine learning Bayesian learning is formulated & Lattice Boltzmann
• AI will be embedded in the long/short term memory.
• Modelling sensor based. Home sensor, distribution sensors.
• Water quality: Fuzzy mathematics.
• Scattered plots and various plots are required.
• First Algorithm
• Alternating Least Square method: Missing information is accounted for.
• Can recover missing information.
• In ordinary least square method coefficient is deterministic
• Lot of missing information is present in primary plotting. Many of the times

the data is not normally distributed. We should represent it as the median.
• What methods for management and modelling,
• Sending – metering and real time analytics and data. Smarter water management with the help of artificial intelligence.
• Supply chain management from another sector.
• STN- non stationarity
• Summary: WRM management is critical
• Spatio-temporal network is mapped.
• Parallel model : Chapman Enskog Model
• Navier Stokes Equation – Macroscopic.
• Cannot describe a microscopic phenomenon cannot be embedded by a macroscopic phenomenon.

Groundwater Modeling:

• Standard modeling, linear flow paths assumed in Darcy's law.
• New component, dispersion, chemical reactions
• Current Approach is
Lattice Boltzmann Model and Machine Learning Model.
• Experiments not deterministic. > Possibilistic.
• Possibility models and not probabilistic models to be emphasised.
• Lattice Boltzmann modeling applied in Rock, and Fractal models. -
• Machine Learning Algorithm and suitability.
• Learning depends on memory (Markov process and fractal phenomena gives long
memory)
• Down trend in the dynamic level.
• Selection of the right algorithms
• Artificial neural network – Feature extraction is separate from classification
• Deep Neural Network – Develop models that combines feature extraction and classification together.
• Bayesian statistics – Likelihood concept and prior.
• RNN – Recurring neural network.
• Long Short-Term Memory – Leads to anomaly, defects. Detrended fluctuation Analysis and smoothens data.
• Verification : Validation
• Model Performance: > Data processing > Common water quality indices

Interactions:

Q: What should be the optimal data size required for optimal prediction
A: If Deep Neural Network: Generally, more data is more predictive ability. 50 sets of data will be sufficient for a machine learning model.
Q: Biggest challenge is to simulate model
A: Lattice Boltzmann method , GPU method, At any point of time you can tap the result which is not possible with any other model.
Q: Cross disciplinary possibilities?
A: Lattice Boltzmann model is the right model
Q: Parameters on pH disaggregate the data?
A: Segregate the short term and long term / pH, limitation of the index.
A2: Basic deterministic way, possibilistic method, using blockchain.
Q: Method applied depends on data collected. Data sanitation not stable, pre monsoon post monsoon data may differ. How to deal with these outliers.
A: Anomaly detection using fractal data is nothing but an outlier detection, rough and noise
data to be removed. Random forest will segregate out. After segregation.
Q: Data from DRDO: Army TERRA-I , only data required by the army is to focus

on: drinkable, not drinkable, drinkable with treatment. WQI
A: WQI is a deterministic method. To avoid all degrees of fallacies, degree of match rather than water quality index.
Q: Enhancing parameters, like fluoride, arsenic, uranium, current knowledge is highly limited.

Chairs Remarks:
Thanks to all members highly engaging discussion. The future is multidisciplinary and integrated approaches.

5. Lake Quality Assessment and Case Studies

This session gave an insight on sustainable management of lakes by measuring water quality, social and environmental aspects of urban water bodies, impacts of sewage mining on urban lakes, spatial methods of analyzing water quality, methods of analyzing urban flood scenarios due to encroachment of lakes and various methods of measuring water quality in lakes. The scale of each of these projects ranged from analysis of an individual lake to Global lake scenarios with case studies from Bengaluru, Puducherry, Kerala and the world as a whole. Use of present technologies and skilled use of software to measure and analyze water quality were some of the innovations observed in the presentations.

One of the case studies highlighted new and vibrant concepts such as Environmental place making that talked about the connectivity and interactions of the lakes with the local population. A special mention of one of the case studies was about analysis of urban floods using HEC-RAS and SWMM software models under various low impact development scenarios provided an approach to know the effects on floods by depletion of lakes and methods to reduce floods around the catchment and lake areas. Sewage mining by industries and its impact on lakes was also interesting discourse. Using satellite imagery and its ability to differentiate land cover based on a thermal setting was creative approach in the analysing water quality. One of the case studies mentioned that the consistent effects of climate drivers indicate global water quality will deteriorate with climate change (reduced rainfall and warming). And other case study addressed the old, traditional and cost-effective solution method to reduce pollutants from the water bodies with the help of aquatic plants.

Overall existing interventions does not address the water quality issues. Water quality simulation models can assess the effectiveness of various interventions on lake water quality. And the presentations were applied based solutions to sustainable management of urban lakes.

6. Innovatively addressing WEF nexus challenges

Panelists: Dr Hong Yang (Swiss Federal Institute of Aquatic Science & Tech), Dr Richard Lawford (Morgan State University) and Dr Aditi Mukherjee (IWMI)

The session tried to address the challenges involved in bridging social and are physical sciences related to water, energy and food security (WEF). The session was chaired by Prof. Rabi H. Mohtar (American University of Beirut and Texas A&M). He discussed the state of the art and current challenges of WEF Nexus and its connection to the SDG applications. The other panelists Dr Hong Yang (Swiss Federal Institute of Aquatic Science & Tech), Dr Richard Lawford (Morgan State University) and Dr Aditi Mukherjee (IWMI) highlighted the importance of tools and modelling for WEF nexus, the relevance of Interdisciplinary research approaches and Water-Energy-Food Governance respectively.

Inequality and variability in the distribution of water, conflicts related to allocation model, non-sustainable consumption and non-sustainable business models in the WEF domain were identified as major challenges. The scale of the challenges can vary from the individual level to the national level and world level (SDGs).

Lack of policy coherence and "out of the box" thinking was identified as some of the major barriers in the present system. The need for a combined crop and hydrology model was also highlighted. The dearth of interaction among scientists, engineers and practitioners from different domains like climatology, hydrology, governance in the present system was also discussed. In the Indian context, the strong links between various issues like poor groundwater situation and food security requirement, electricity subsidy for farmers and over-exploitation of groundwater also came up in the discussion. It is essential to have interdisciplinary collaborations. To promote it, common goal setting for experts from different disciplines that benefit their sector was suggested. From the tool's perspective, usage of the Sankey diagram was recommended to capture two-way interactions between water and energy transparently. WEF Nexus involves various trade-offs. Tools and data can help in optimizing the trade-off in various scenarios. However, the limitations and uncertainty involved in the usage of the model were also recognized during the discussion. The need for including the ecosystem services in the WEF nexus was also mentioned. In the Indian context, re-aligning food procurement policies was suggested as one of the methods to handle groundwater depletion. Different incentives for the farmers for using less water may also help.

The session was concluded by suggesting a new value-based business model where the rules of the game need to be changed. As per this model, the output of the farmers will not be measured in terms of the tons produced per hector. Instead, it needs to be measured in terms of different indicators like nutrients, proteins, water footprint, energy usage and environmental parameters. This new business model would help us in building resilient and sustainable communities.

7. Data Issues and Needs Related to Monitoring Sustainability in Water Space

Oscar Baez Villanueva: Improving the spatio-temporal representation of precipitation in data-scarce regions

An accurate representation of the spatio-temporal variability of precipitation (P) is challenging over data-scarce regions when only ground-based measurements are used because it is subject to large uncertainties. Several P products are currently available; however, they still present multiple sources of errors. This makes their application difficult for operational purposes. Despite the improvements in the spatio-temporal representation of P patterns derived by these methodologies, only one P product is typically selected to compute the final merged dataset. There are different studies that aim to merge P products with ground-based information. Despite the improvements in the spatio-temporal representation of P patterns derived by these methodologies, only one P product is typically selected to compute the final merged dataset. Therefore, valuable information that is better captured by different P products (e.g., detection, spatial extent, and magnitude of certain events) is not taken into account. This study aims to develop a merging methodology with the aim of improving the spatio-temporal characterisation of P. Random Forest Algorithm – accurate, does not produce biases and does not cause overfit.

Subhash Yeggina: Spatial downscaling of satellite remotely sensed soil moisture and rainfall over Karnataka

In Indian context, the regional rainfall products that we have are from IMD, available at 0.25-degree resolution with a temporal latency of 1-2 years. In data-scarce regions the interpolated rainfall may not be appropriate. Satellite based products (used for rainfall runoff modelling) do well on monthly scales but have lot of bias at daily scales. Spatio-temporal disaggregation of satellite-based products and IMD rainfall data Soil moisture was spatially downscaled to 20 m. The downscaled soil-moisture will be used to disaggregate the rainfall. Groundwater modelling using the interpolated and disaggregated rainfall is being planned.

Pranuti Choppakatla:

Calculating satellite derived bathymetry (SDB) of Mettur reservoir over time to show the decrease in the capacity of the river due to accumulated sediments. Reliable reservoir storage estimates are critical to addressing water disputes. Present calculations rely on expensive field-based techniques using DGPS and echo sounder are the most widely used for volume estimation. Innovative techniques such as satellite-derived bathymetry using Stumpf equation provide cheaper alternatives for the regular monitoring of reservoir capacities to assess influence of sedimentation.

8. Freshwater Conservation and Development Planning: Novel Integrative Approaches and Big Data

This was one of the only sessions of the conference to focus on sustainability from an ecosystems and biodiversity perspective. Freshwater ecosystems make up less than 1% of the land surface but account for a significant component of the world's biodiversity: ~40% of the fish species and one in three species of vertebrate animals. However, several speakers highlighted the alarming collapse of freshwater biodiversity, noting that populations of freshwater species have declined more than 80% since 1970 – a rate that is double that seen on land or in the oceans.

An 'Emergency recovery plan' to 'bend the curve' of freshwater biodiversity loss was proposed, identifying 6 priority actions: 1) accelerating implementation of environmental flows, 2) improving water quality, 3) protecting and restoring critical habitats, 4) managing exploitation of freshwater species and riverine aggregates, 5) controlling invasive species, and 6) safeguarding river connectivity. Key recommendations were made for new and revised targets and indicators for the Convention on Biodiversity (CBD) and Sustainable Development Goals (SDGs) in 2020.

Two of these issues were highlighted in presentations, on the importance of flow regimes to sustain biological and cultural diversity, and on the magnitude of change in river fragmentation at the global scale. Neither threat is adequately addressed in any of the current CBD and SDG targets and indicators. A Connectivity Status Index was presented, providing a robust indicator to quantify fragmentation and safeguard river connectivity. A curated global dam database (Global Dam Watch) was described, providing an important tool to assess these major stressors of river ecosystems through disruption of connectivity and alteration of flow regimes.

9. Resilience in Urban Water Systems: Methods

This session addressed challenges of household water access in a 24/7 water supply scenario for Coimbatore, the projected influences of LULC and water usage changes in the Cauvery basin, finding multi-objective optimal solutions for water distribution networks in the case of Pamapur district, Telangana, identifying key points of intervention across urban water network in Bhubaneshwar and Dehradun, and treating industrial wastewater contaminated with Chromium and Arsenic.

Science and methods:

Data collection methods and sources for the 24/7 water supply study of Coimbatore included household surveys, water diaries, metering, and pressure sensors put in multiple sources to estimate baseline water access. Scenarios of sufficiency, equity and fairness from multiple sources of water in a 24/7 piped water supply were then estimated. The Cauvery basin study made LULC projections for 2040 based on LULC maps between 2000 and 2018, applying various sub-models

and transition potentials. Urban water and agriculture water demand were also estimated using calculations involving LULC changes. NSGA-II algorithms were used to calculate minimization of cost, maximization of resilience and minimization of greenhouse gas emissions, which were taken as the three parameters to find a range of pareto-optimal solutions for water distribution networks. Two smart cities, Bhubaneshwar and Dehradun, were identified to study their water flows on the basis of their population size, water stress and non-revenue water loss. Water flow across their water supply and distribution networks was assessed using Sankey diagrams, and energy consumption across the water system as well as the carbon footprint of operations along the network (using Umberto) were also calculated.

New capabilities/innovations:

Using sufficiency, equity and fairness as parameters to understand household access to water supply and estimating future scenarios is suggested as a good way to understand how transitioning to 24/7 water supply will influence water access and behaviours of individuals in terms of which sources of water supply will continue to be used, and this can help shape policies accordingly. A case for incorporating changes in LULC and water use into projections for future river water usage is made, since these changes will affect water demand, allotment, and therefore any conflict over river water usage as well. Since problems of water management often involve multiple factors to be taken into consideration, finding pareto-optimal solutions between various such factors using NSGA-II is recommended to opt for better-suited solutions for different locations. Studying water flows, including considerations of energy and carbon emissions, can also help identify effective points of intervention for city planners and policymakers in order to ensure water security and energy sufficiency in India's rapidly growing cities. Two minerals, Saponite and Nantronite, have been found to be able to treat water contaminated with hexavalent Chromium and another mineral, Schwertmannite, has been found to be able to treat water contaminated with Arsenic. All three of these minerals occur naturally in the Deccan region of India and various chemical treatment processes using these minerals have been devised to treat contaminated industrial wastewater, which could then be reused.

10. Governance: Knowledge Management and Innovation

The challenges addressed in this session included wastewater management and the circular economy of wastewater in the case of Delhi, planning and implementation of small scale urban water projects, resolving the groundwater crisis using micro-irrigation technologies in the dark regions of Gujarat, knowledge synthesis for the water crisis scenario and assessing school-level curriculum for interest of students in STEM and water-related issues in a rural government school in Odisha.

Science and methods:

The study of Delhi's circular economy

of wastewater involves assessing various decision-making frameworks based on literature review, secondary data available in the public domain and a few stakeholder interviews, which have been used to identify gaps in current processes and suggest better practices. The impact of micro-irrigation adoption on groundwater extraction is evaluated based on an estimation of groundwater levels over time and regression-based descriptive statistics. The study on STEM education and addressing water-related issues in school involved an analysis of the weightage of water-related topics in the class 8 syllabus, surveys and direct observation of students' interests in STEM and water-related issues, and a statistical test to determine whether modifications in curriculum and teaching methods influenced students' interest levels.

New capabilities/innovations:

The current approach to treating groundwater, focused on pathogens, is rejected as being outdated and insufficient and an alternative six-barrier water treatment process is suggested, in compliance with a 'one water' model that requires treated water to be of potable standards. This 'advanced water treatment' process involves treatment against pathogens and various chemicals and has been tested extensively. An improved water reuse plan for Delhi is recommended along with a strong case for the integrated governance structures, involving various sectors that could use different amounts of treated water since water demand of the city cannot be met unless water is reused. The advanced water treatment process fits in very well with this proposed water reuse plan for sustainable water management. A 'City Rehydrate' toolkit is developed to analyse and implement small scale urban water projects, based on derived principles and application-based modifications. This toolkit aims to facilitate the planning and implementation of such projects since it considers various elements and relationships as individual parts of a whole. The study on the impact of adopting micro-irrigation techniques on groundwater suggests that adopting such techniques alone does not result in any significant change in groundwater extraction levels, however, combined with metered water supply, a decrease in groundwater extraction levels are observed, and it is therefore suggested that institutions and measures to ensure proper metering of water supply be put in place to help regulate groundwater extraction.

11. Water-Energy-Food Nexus Governance

Presenters: Mr. S. Ashwin Ram (Madras School of Economics), Dr. Debashish Sen (People's Science Institute, Dehradun) and Mr. Balsher Singh Sidhu (University of British Columbia, Canada)

The session tried to deal with the challenges involved in the socio-economic scenario, and its science related to Water, Energy and Food (WEF). The session was chaired by Dr. Vinay Nangia (International Center for Agricultural Research in the Dry Areas, Jordan). The other panellists were Mr. S. Ashwin Ram (Madras School of Economics), Dr. Debashish Sen

(People's Science Institute, Dehradun) and Mr. Balsher Singh Sidhu (University of British Columbia, Canada) engendered the advantages and disadvantages of the government policies through different case studies and literature survey.

The modelling and the case studies were studied through the secondary data, which includes literature review, or the surveys conducted in the different localities. The potential of the WEF nexus to contribute to the achievement of the Sustainable Development Goals were discussed in the session. The strong links between various issues like groundwater depletion, different power pricing structures for farmers and over-exploitation of groundwater were highlighted. The different aspects of the policy making were discussed during the session.

The government projects and policies need to be facilitated with the local communities so that both the parties are benefitted. An approach like Grievance Redressal Mechanisms (GRM) which aims to resolve disputes between the developers and local communities through third party interactions was suggested in the session. Educating or creating awareness in the local community regarding the different policies and the over exploitation of the resources was also recommended.

The session was concluded by promoting an important point in the policy making which does not only involve water in isolation but also an interrelated aspect. The water policy along with the consumption pattern of the crops and farm prices, all together needs to be considered while suggesting a change to the policy makers.

12. Water Issues, Assessing and Meeting Sustainable Development Goal 6

1. What are the major challenges addressed in the session and what scale do they manifest?

One of the major water challenge addresses in the session is the sanitation in the context of children in the rural areas. This challenge manifests deeply into the lives of the rural population as lack of sanitation facilities and clean water can lead to health issues that can be life threatening and hence, rendering rural dwellers, especially, children and women folk vulnerable. The session also addressed the issue of desalination of saltwater and related water security assessment. Though desalination provides resilience to water scarcity, it is not free of ill effects. Brine discharge from the desalination unit has adverse effect on the local marine life. Another issue which is very crucial in meeting SDG is the availability of data and the session addressed the role of data in SDG monitoring. Lack of data is a challenge as it hinders the assessment of progress and reporting relative to achieving the SDGs. There are 17 SDGs, 169 Targets and 232 Indicators and they require robust data for assessment and monitoring. Data is very crucial for proper management of resources and bring about nexus between water, energy and food and meet the water targets linked with energy and food.

2. How has the science addressed the challenges and what are the limitations?

Scientific research at the ground level including 200 participants was conducted and community-based management was promoted to better deal with sanitation for children and wastewater management. The issue regarding the lack of data has been addressed with the usage of satellite data. It provides base line information with synoptic view and global coverage. However, satellite data is periodic and requires ground truth for calibration and validation. Further, it cannot provide indigenous and traditional data.

3. What are the new capabilities and pathways needed? What are the major innovations?

Capabilities to articulate the problems related to sanitation needs to be developed among the rural children and women. Though the number of toilets in the rural regions has risen, the toilet facilities are not children friendly. And most importantly, lack of clean water supply has rendered them useless. So innovative idea of collaborating with children and including them in the dialogue to identify issues was applied. In the context of increasing number of saltwater desalination units, innovative methods are needed for safer disposal of brine. Further, to fill in for the lack of data, high spatial and temporal resolution data are used to study resource availability, integrated water management and transborder water issues and geospatial data are used as to develop indicators.

13. Agriculture and Water

In India, about 80% of surface freshwater is utilized for agriculture. Along with water, chemical additives of varied sorts which are added to the soil for enhancing agricultural productivity also end up into the same water bodies. In such cases, contamination of surface waters from agricultural run-off becomes a concerning issue.

In this session, one of the key water challenges highlighted was the contribution of agriculture to surface water contamination. The use of low-cost indigenous adsorbent materials obtained from agricultural waste products like rice husk, coconut shells etc. was proposed to reverse the very impact caused by agriculture itself. The scenario of rain-fed agriculture in India was also tinted with observations which displayed 40% of our country's food production being solely dependent on natural rainfall. With climate change manifesting as erratic monsoon patterns and un-predictable drought conditions the gravity of this situation becomes even worse. Accuracy in prediction thus becomes very essential for us based on which we can strengthen the resilience of our farming system. Development of simulation models that incorporate both sub-seasonal and seasonal variability especially in terms of temperature and precipitation can prove to be very handy. With climatic variability, a restriction on water use also follows. It becomes extremely vital for agricultural practitioners to manage their water usage while also providing optimum water to the crops for maximum growth. This is the stage during which intelligent computational models and machine learning becomes tremendously useful both in terms of versatility and efficiency.

These systems are incorporated into irrigation units that monitor parameters like crop growth stage, soil moisture content, cropping pattern, existing temperature and humidity of surrounding environment and other dependent factors to determine the optimum water to be provided. This information is then conveyed to delivery systems which regulate optimum amount of water provided to crops thereby promoting economic management of water resources.

Use of satellite data and remote sensing have also been employed in agricultural systems to facilitate economic use of water while also maintaining sustainability in usage. Additionally, 3-dimensional crop architecture modelling was discussed as an efficient tool to address the challenge of food security in the country. To summarize, further studies are warranted for each of these scientific contributions and innovations. Further development of a single sustainable framework equipped with intelligent technology, weather data and soil characteristics (to determine optimum water uptake by plants) still remains the need of the hour.

14. Analysis of Groundwater Contamination

This session on groundwater quality and assessment, dealt with some of the following themes; the first theme dealt with the challenges of water quality data and surveys in the North East part of India, given some of the critical and sensitive nature of conducting this work. The second theme that was presented, examined the possibility of low-cost boron doped carbon dots as an efficient means of the determination of PPB levels of arsenic in environmental samples. The third and final thing that was presented, examined low arsenic groundwater sources in the Western Bengal Basin which was an exploratory study with a lot of possibilities.

Challenges:

Major challenges addressed in this panel: all three themes primarily presented the complex science that goes into addressing the question of water and the social challenges that it poses. The first tries to address critical and sensitive issues around collecting water samples in border areas and providing safe drinking water to both villages and the Army. The second more critically addressed low-cost means and measures to identify arsenic (III), in environmental samples this was effectively one of the most innovative outcomes of this entire panel. The third mapped out water sources in the Western Bengal Basin, identifying aquifers and Paleo-channels, focusing on sediments in the Paleo-interfluvial channels to identify arsenic deposition. Some interesting observations emerged around arsenic sequestration where the exposure to pollutants and wastewater was found. Although the scale that these challenges have manifested are in limited regions, it is certainly possible that their applications, observations, outcomes can be scaled for interventions across specific challenges across the globe.

Contribution of science:

In the first theme sciences made a critical intervention in both matters of security as well as safety in the border regions of the

country, critical scientific intervention both timely and measured have necessitated dialogue of peace in the north-east region of India. The second theme was highly innovative in that complex nano materials are applied to specifically test for arsenic but have multiple applications across a plethora of uses and applications comprising of water testing, biological testing, fluorescent bio imaging, drug delivery vehicles, and with multiphoton excitation having a very broad spectrum of applications. The third theme found probably accidentally the possibilities of arsenic sequestration in contact with wastewater that can be explored in the Western Bengal Basin.

Limitations of science:

The limitations of science in this area, including social science, have been effectively addressing large scale or global scale mitigation patterns that can be culled out from these experiments, we are looking at developing new methods, techniques, materials, also new imaging systems, at better understanding the complex processes that drive groundwater quality assessment systems.

New capabilities:

The quality assessment paradigms open up to tracking pollution that are both anthropogenic and geogenic including the complexity of anthropogenic sequestration of geogenic pollution. New mechanisms of low-cost detection are extremely important in cross applications specially in the case of nano materials, a better understanding of paleochannels and geogenic contamination also leads to possibilities of developing effective sequestration strategies. Key recommendations to this effect would be to develop more comprehensive nano material detection strategies including but not limited to boron doped carbon dots, their applications at micro level areas where costing plays a crucial and critical barrier. Access to low-cost strategies would therefore mitigate through effective information contamination potential. Other recommendations would be to explore sequestration strategies for arsenic and other heavy metals in situ, while also exploring low arsenic and safer means of groundwater extraction. Effective mapping systems of water quality, remote sampling perhaps, and up to date in almost real-time data are critical parameters near border areas that require more application.

Innovations:

Some of the designs of the DRDO, an effective large-scale water purification system with 15-year life span is an automated recharging mechanism are of considerable interest in rural applications; it is also possible that they may be deployed in highly dense urban areas during critical disaster periods for safe drinking water. Whether such cross application is possible requires more introspection, but certainly developing the stream of thinking towards portable hardened and long-term systems of water filtration is of critical national interest. On the other hand developing low-cost testing mechanisms for not only arsenic but other contaminants that are both anthropogenic and geogenic perhaps iron, fluoride, nitrates, carbonates, magnesium, nickel, lead, and other effluents and wastewater are critical for an emerging future of water where three conditions are established; too much water; too little water; too polluted water. Sequestration strategies that can be explored in situ and other mitigation strategies for geogenic contamination are critical going forward.

15. Case Studies of Water-Energy-Food Nexus Solutions and Implementations

Presenters: Dr. Pawan Sable (ICRISAT, Hyderabad), Dr. Bhargavi Tadipatri (Vijaya College, Bangalore), Dr. Hong Yang (Swiss Federal Institute of Aquatic Science and Technology, Switzerland), Prof. Jamie Pittock (Australian National University) and Dr. Andrea Momblanch (Cranfield University)

Water, energy, and food security are highly interrelated and hence need an interdisciplinary perspective to understand their interactions. This session addressed five interesting case studies of Water-Energy-Food Nexus analysis and implementation in Asian countries. The session was chaired by Prof. TS Gopi Rethinaraj from Divecha Centre for Climate Change, IISc, Bangalore. Panellists included Dr. Pawan Sable (ICRISAT, Hyderabad), Dr. Bhargavi Tadipatri (Vijaya College, Bangalore), Dr. Hong Yang (Swiss Federal Institute of Aquatic Science and Technology, Switzerland), Prof. Jamie Pittock (Australian National University) and Dr. Andrea Momblanch (Cranfield University) who presented the case studies of WEF Nexus from India, China, Mekong river basin and Himalayan river basins in India. The presenters highlighted the multi-sectoral expanse of the nexus concept, system complexity and the importance of better understanding of water-energy-food nexus for better management of natural resources.

The need of multi-modal approach that can capture the trade-offs in the complex system and uncertainty in climate projections was highlighted. Also, development without damaging the natural resources and robust management of present natural resources were identified as key messages in the understanding of WEF Nexus. The scale at which these issues have effect can vary from an individual (local farmer) to regional (command areas of reservoirs) to national to global level.

Implementation of a WEF Nexus solution requires cooperation among scientists, engineers and practitioners from different domains like climatology, hydrology, governance and local population. The lack of interaction between these entities was addressed in the session. In the Indian context, the need of collaboration with the local farmers who are the real stakeholders in the agriculture was discussed. The interrelation of irrigation systems, crop patterns, electricity subsidy for farmers and food security was observed to be an important aspect in Indian agriculture system. A simple method to quantify the irrigation water needs and energy consumption in different cropping systems was discussed. Changes in the crop pattern and irrigation system can help utilise both water and energy resources more efficiently in the dryland agriculture. The concept of Water Energy Integrated Farm Factory was introduced. This model revolves around introducing corporate culture in agriculture and thus making farmers agriculture professionals which will benefit as there will be more research and development, food and nutrition security in agriculture sector.

A case of hydropower dams in Mekong river delta showed how it would affect biodiversity and food security in four developing nations viz, Thailand,

Cambodia, Las and Vietnam. The effect could also be more far-fetched affecting the countries' economy, and GHG emissions. Another study drew the line between irrigation, reduced stream flows and hydropower potential in China. The issues addressed in the presentation combine different sectors and can be of interest to policy makers and utility mangers. A case of water resource management in the two Himalayan river basins in the view of WEF Nexus was presented. The vast change in the topography from plains to mountains and water availability from seasonal snow and glaciers makes this region more complex and vulnerable to changing climate. This study brought out the important facet of nexus modelling to include natural environment. It also highlighted the cultural sector (aesthetics, recreation and tourism) in the nexus modelling and future projections.

The session was concluded with the message that understanding of WEF Nexus requires flow of information from various domains. Domains involved may change from place to place depending on the complexity of systems. Also, multi-modal approach can be adopted to better understanding of modelling trade-offs between these domains.

16. Groundwater Quality and Assessment II

Session Summary

In this session the speakers discussed about the challenges related to overcome groundwater overexploitation.

Abilash Paswan discussed about the implementation of Decision Support Tool for Groundwater Water (DST-GW) management using both hydrogeological and climatic data from 2011-2013 over Tumkur watershed in Karnataka to understand the temporal groundwater resource evolution. Subash Chandra discussed on aquifer mapping employing heliborne geophysical (electromagnetic and magnetic) methods in granitic hard rock terrain and adaption of the same technique to map large scale fractures and groundwater pathways using transient electromagnetic (TEM) data in combination with geological and borehole information. The main aim of the study was to acquire Knowledge of fractures as it is important for groundwater exploration and for selecting sites suitable for managed aquifer recharge for water sustainability. Srinivasa Vittala discussed about the detailed extensive village level hydrogeological survey conducted in Koratagere Taluk of Tumkur district, Karnataka and mapping of lineaments using high resolution remote sensing satellite data products. Their study was carried out to pinpoint the feasible sites to take up groundwater exploration at village level which can cater drinking water needs in a severely water stressed Bendoni village. Amit Sharma discussed about the study which was conducted using multi-source satellite remote sensing datasets to monitor groundwater irrigated croplands for the kharif, rabi and summer cropping seasons. The main aim of the proposed study was to demarcate vulnerable hotspot areas in the watershed by understanding the interaction between seasonal cropping pattern and groundwater dynamics

at watershed scale. He recommends creating awareness among the farmers to adapt sustainable agriculture practices would perhaps the best way to escape from the onslaught of slow ecological disaster.

Chair's Report:

1. Dr. Suryanarayana of CGWB, Government of India presented paper on Village level hydrogeological, remote sensing and lineament mapping for sustainable groundwater development-Case study in a severely water stressed area in hard rock terrains of Southern India . He explained the role of lineaments in selecting the location for the high yielding borewells guided by study of Remote sensing data. He quoted examples from Tumkur district, Karnataka. This study was on a micro level.

2. Amit Sharma, University of Rennes, France presented paper on Groundwater irrigated cropland monitoring using multi source remote sensing data. In this paper the application of Remote sensing data to establish the depletion of groundwater in a given location as well as in the basin was explained. This would help in conserving the groundwater potential in any given area for proper water resource evaluation by selecting different crop patterns. He opined that proper selection of crop pattern for the better management of water resources. He also mentioned the increase of nitrates along the fracture zones due to anthropogenic activities

3. Dr. Subash Chandra, NGRI of CSIR presented paper on Mapping of fractures and groundwater pathways in hard rock by heliborne geophysics. In this presentation remote sensing data-based aquifer mapping by EM-TEM survey and follow up groundwork for evaluation of ground water potential In hard rock terrains of Southern India was discussed at large on regional level.

4. Dr. Abhilash Paswan, NGRI of CSIR presented paper on Groundwater management in Semi-arid area: A case study from Tumkur, Karnataka, India. He attempted integration of meteorological data with the geological structure for groundwater evaluation on regional basis. He highlighted the significance of structural cum geological studies for proper utilization of groundwater management with specific reference to Tumkur, Karnataka, India.

Challenges:

1. What are major water challenges addressed in the session?

This session was dedicated to the ground water assessment based on Remote Sensing studies. All the 04 papers presented highlighted this aspect. In two papers Illustrations were drawn to the water quality particularly the nitrate and fluoride enrichment along the fracture zone the Nitrate enrichment was attributed to anthropogenic activities.

2. Please describe the scale at this challenge are manifested?

Majority of the papers presented was confined to semi- arid regions in district level, only a passing reference was made at regional level. One paper however explained the importance of remote sensing on Regional level supported by multi spectral data.

Contribution of science:

1. How the science (methods, data, models, tools) has addressed the major water challenge?

Application of Remote sensing data and groundwater resources were discussed

2. What are the limitations of the current scientific methods and institutions (including social science) in addressing the challenges?

Remote sensing data requires validity check-up at the ground level in order to arrive at correct conclusions.

17. River Basin Governance

This session primarily addressed challenges of transboundary water conflicts in various river basins, including the Mahanadi river basin, the Ken-Betwa river linking project, rivers in the Keonjhar district of Odisha, and it also addressed how to build capacity to resolve such issues.

Science and methods:

The estimated future water use of the Mahanadi river in business-as-usual trends is calculated, which shows that all but the environmental flows are sufficiently accounted for. The Ken-Betwa river link project study comprised a comparison of precipitation, morphometry and the state of groundwater in both river basins. A framework to assess water conflict vulnerability is developed as an indicator of the state of water management, applied to a project on Baitarani river in Keonjhar, Odisha. This study involved community stakeholder engagement as well. And the final presentation recommended certain roleplay games for better conflict resolution, on the basis of recorded experiences in different workplace settings.

New capabilities/innovations:

An alternative sequential prioritisation for the allotment of river water use is suggested, which puts water for life, ecosystems and livelihoods at the foremost, followed by allotment for adaptation to change and then for industrial and commercial usage. This approach accounts for all uses of water and any gaps in the overall water balance is suggested as possible to meet through institutional and governance mechanisms. The study on the Ken-Betwa river link project suggests the need for further investigation on the scope of groundwater development, rainfall variability and climate change impacts on the river basin, as well as the need for proper justification for the river linkage before the project begins, all of which can be applied to other such projects in other rivers. Water quality and vulnerability assessment as well as community stakeholder engagement are recommended as musts in the planning stages of any river basin project. Roleplay games are also recommended for different stakeholders to engage in, with the aim of making players understand different standpoints during the negotiation process and become more transparent and cooperative during situations of conflict. This session therefore came up with a number of different recommendations to improve transboundary river conflict resolution, including different approaches to water usage allotment, different considerations in the planning process and building capacity for the actual conflict resolution process.

18. An Integrated Global Vision for Water Security: Approaches and Methods

The challenges addressed in this session include lack of communication and knowledge mobilization in projects based on past and ongoing projects by Global Water Future in Canada, the need for capacity development in the context of Africa, water security in the Cauvery river basin and in the mountain regions, specifically Darjeeling.

Science and methods:

The presentations on knowledge mobilization and capacity development were based on inferences made on observations of past and ongoing projects. The Cauvery basin study looked into future scenarios of water security using VIC and GWAVA models to study hydrological changes and anthropogenic influences respectively. The projections were based on combined climate and socio-economic changes, along with different management scenarios. The study on Darjeeling looked more into the aspect of access to water, by means of stakeholder interviews and household surveys.

New capabilities/innovations:

Knowledge mobilization has been found to be an effective way to build relationships between various stakeholders and to involve community members in research/implementation projects so far and is suggested to be included in all projects, following an initial stakeholder meeting, in order to connect with users to address their solutions and subsequently communicate new solutions to them. Reforms in current education systems to increase one's capacity, requirement for more communication with stakeholders, smart water infrastructure and multi-use framework are suggested to address issues of water security and planning, especially in Africa. Findings from running various models in the Cauvery basin indicate pathways and behaviours are more sustainable for water access, which should influence policy decisions. Such models may be applied in other catchment areas to direct policy decisions there as well. And the study on water access in Darjeeling shows that in spite of being a water-rich area, many residents do not have access to public water supply and rely on non-public water supply, generally priced much higher, to meet their consumption needs. This suggests a very different finding from the general assumption that people residing in water-rich areas do not face issues of water access and calls for changes to be made in institutional and infrastructural systems to improve upon this.

19. Interlinkages in Urban Water Systems

The presentations gave an insight on water quality and sanitation methods in peri-urban areas, effects of urbanisation on extreme precipitation events and the interlinkages of urban forms on energy balance and local climate. The various case studies moved from small towns to city to Country scale. One of the case studies in the outskirts of Bengaluru analysed various forms of sanitation followed and its subsequent spatial mapping. Another case study took India as

an example with 34 major urban centres as main points within the time frame from 1973 to 2007. The spatial mapping for the Urban centres with it is change in extreme rainfall event was modelled and run within the various time steps. The study concluded with spatial non-uniform distribution trends across various regions. The last study considered meteorological data, spatial forms on classification and various heat components as input for various scenarios in the Mumbai region was run on the software SUEWS and its relative effects on humidity, temperature and evapotranspiration rates was observed. Scenarios with change in land pattern and it is following effects provided a clear indication on local climate change with increase in urbanization. Innovations in household surveys for answering questions about sanitation, using computerized models to run various scenarios on a city scale and country scale is to be highlighted. Overall the interlinkages of Urban water systems with sanitation practices, local and Global climate were well established.

20. Solutions in Water Quality Management

The unmet demands of water supply for an ever-growing population have always been a challenging issue in today's world. Over-exploitation of ground water from natural aquifers, decline in the productivity of wells, ground water pollution and contaminated surface water bodies have further added on to the severity of this situation. Increasing population numbers and the associated demands associated with it seem to be the source of the issue. In India, the NCT Delhi region, including cities like Delhi, Gurgaon and Faridabad have already become a part of the negatively impacted zones of the country.

Due to intensification of industrial activities, studies show that the groundwater in these areas display salinity concentrations of a magnitude that can be quite concerning, the high salt concentrations being attributed to the presence of various fluorides, chlorides and bicarbonates. Moreover, reports also indicate that the rate of evaporation that occurs is quite significant and is in no way comparable to the extent of recharge. All in all, what can be made of the situation is that water, a crucial component of our survival is on its way to reach crisis unless we understand the gravity of this issue and work towards it. Another issue that is slowly coming into the picture is the contamination of our water supply with pathogenic micro-organisms. A myriad range of micro-organisms are present in water bodies and although not all may be harmful, there are some which can cause serious implications on our health.

Science has contributed to the filtration and sterilization of several of these pathogenic agents especially Vibrio and E. coli species (responsible for most of the water-borne gastro-intestinal problems) via the development of a vast variety of silver, gold and copper nano and ultra-filtration devices also functional as anti-microbial agents. However, this has only led to a newer problem, the evolution of multi-drug resistance species that are in no way affected by the anti-microbial agents used for filtration. Many of the new

technologies developed in this direction have only led to added risks than useful solutions. While many believe that there remains a need to develop innovations to overcome these water issues, some may argue that an amalgamation of newer technologies with the age-old conventional practices can still be a key to the problem.

Traditional methods may have been inadequate especially in terms of the sludge generation and disposal but in association with newer techniques like electrochemical oxidation, use of gamma-rays, ultra-filtration etc., the filtration and sterilization process can become quite effective. For instance, nanofiltration with chlorination can be a two in one approach, where nano-filters separate out the biological agents and chlorination works to sterilize a system with any residual bacteria. NITI Aayog reports indicate that about 21 of our cities will reach day zero by 2020. Further reports suggest that about 61% of our ground water levels have been consumed.

There is very little water left for consumption. With very little time on our hands, there is a need for us to spring into action before the water issue reaches a state of crisis. A very simple way we can contribute towards sustainable water usage is by adopting sustainable water management practices such as water re-use and recycle. For this, wastewater treatment becomes quite crucial. Several nano-fibrils and natural based biopolymer materials from domestic waste materials are being employed as absorbents for a cost-effective, energy efficient and versatile treatment process with high removal efficiency. However there still remains a need to scale-up the applications and evaluate feasibility before large scale adoption and use.

21. Water Ethics: Concepts and Approaches

Susan Smith: Transforming water: Towards a life-affirming ethical approach to water management

The speaker addresses the failure of sustainable integrated water resource management (SIWRM) which does not solve critical water resources issues i.e., all life with sufficient and healthy water. The speaker proposes to replace the current paradigm with a Life-affirming Ethical Approach to Water Management (LEAW) which is more eco-centric. LEAW also addresses human dimensions of water justice, set policy priorities which are consistent with our values, ethics and social norms. LEAW combines two distinct strands of thought: water justice ethics and Indigenous water ethics. Indigenous peoples from Latin America, Africa, and Northern India contributed to the EWN-WCC water justice principles based on their cultural understandings. LEAW can be translated into a pragmatic tool for water managers to take the next step towards better water management by assuring that water is shared equitably with all life. By drawing on principles of water justice and the natural water law known to and employed by indigenous

peoples, water can be managed for the benefit of all.

Pawan Kumar: Crashing of Abundance and Scarcity: Exploring Water Crisis in Uttar Pradesh (UP)

The speaker discusses about the water crisis in UP, through a case study of 'Water Rights March' (WRM) which encapsulates the complex relationship between social, cultural, economic and environmental dynamics of water politics. WRM identified water crisis and scarcity with abundance (drinking water in cities like Kanpur and Varanasi) as contradictory variables. The speaker introduces a new approach which focuses on the relationship between democracy and natural resources especially water rather than dams & displacement, river water disputes, transboundary water politics etc. Speaker explains to locate the water and democracy link within new global (regional) and national (sub national) discourses concerning natural resources, and issues around the human-nature relationship. The speaker highlights the water conflicts of the Kanpur city: proxy war on drinking water between citizens and water institutions, construction of dams and power projects, territorial disputes at domestic, national and global level, diversion of Ganga River's water and environmental degradation, water pollution and loss of biodiversity of the river Ganga, etc. The speaker argues that water crisis and drinking water scarcity in UP are arising due to unplanned urbanisation and power relationship thereby dispossessing people's right to water and recommends bringing Equity and Sustainability in Water Policy while focusing on: 1. Effectiveness of governance (local) nexus between access, ownership, control, regulation with caste, class and gender hierarchies in planning and policy formulation. 2. Maintenance of Water Resources (Hydrologic Cycle), Water-life and water livelihood linkages with water for climate change mitigation and adaptations, and various usage hydropower, industrial, and agriculture.

David Groenfeldt: Ethics as Action: Using ethics to clarify water values and create "the world we want"

The speaker highlights to use an ethics-based analysis of stakeholders' water values to counter the decision making which is driven by economic measures. The comparison is made on four approaches to values-based water planning: (1) multi-stakeholder platforms, (2) scenario building, (3) ethical matrix, and (4) water statements. The first two approaches/methods are used for water planning and offer a way for diverse stakeholders to identify their priority water values. The other two is used to allow the stakeholders to critique and debate their own water values. The speaker emphasizes that the matrix approach provides a systematic way to map the water values and helps to identify any missing values and prioritize the included values. The new methodology combines well-established tools of stakeholder engagement (multi-stakeholder platforms and scenario-building) with new tools for identifying and prioritizing water values and ethics. The ethics analysis (the matrix) along with the ethics statement, declarations or charters constitutes a robust way to identify and critique key water values.

Mitul Baruah: "... Before, the floodwater used to come in gracefully and recede faster": Political ecology of the Brahmaputra Valley hazardscape and rethinking the postcolonial state.

The speaker addresses that the flooding and riverbank erosion has led to the loss of landmasses, large-scale outmigration of the local population and devastation of traditional livelihood practices in Majuli River Island, Assam. An ethnographic fieldwork was conducted in Majuli River Island (largest river island in the world) where interviews and participant observations were carried out over a period of sixteen months. The interviewees included community members, politicians, activists and NGO leaders, government officials, contractors and residents. The speaker listed many disappeared and highly degraded wetlands due to flooding and riverbank erosion. The residents of the island criticized the building of hydraulic infrastructure such as embankments which has led to frequent flooding, unavailability of fish and water for farm. The speaker who is a native of the island recommends an in-depth political-ecological understanding of these disasters, and an improvement in environmental policies and politics – moving beyond the existing technocratic approaches.

22. Water Quality Assessment: Case Studies

Session summary:

This session looked at the diverse portfolio of water quality assessment studies covering micro-plastics and water systems in Sri Lanka, application of statistical methods to evaluate and adjust the water quality monitoring systems of the Freiberger Mulde River Basin an offshoot of the Elbe River in Germany, discovering linkages between catchment characteristics using cluster modeling, water quality at scale looking at three case studies in Africa and perhaps most interesting and detailed examination of nitric dynamics in the subtropical waters reservoir. This session primarily addressed five critical challenges; examining micro plastics and their degradation, suggests possible strategies were examining micro plastics and its ability to retain and absorb other toxins, the sampling that was mapped contained very high rates of fibres, and strands and almost no granules. There is no micro-plastic data to start a dialogue together in Sri Lanka and India. The second challenge regarding water management was more complex it looked at complex statistical clustering of quality measurement nodes across the Freiberger Mulde tributary, contamination from effluents released by industrial setups, the primary challenge is that the consistent monitoring network is critical for water resource management the problem is not lack of data per to lack of conclusive time bound systematic data some indices are tested almost in real time whereas other indices are only produced yearly quarterly and in differential timeframes. A total of 463 water quality parameters over 364 monitoring stations contributed data over a period of almost 20 years 1995 to 2016. There are at once large gaps in data, inefficient data,

redundant data, and those form challenge in themselves. The third challenge was to develop for 567 Indian catchment areas of physio climatic model primarily using clustering model and with six indicators across 88 catchments in the country between 2005 and 2007. Spatial metrics are then expressed on the map. The fourth challenge is the world water quality assessment idea is to bring together multiple agencies and build a consortium or an alliance that can rescale or upscale the work and provide a world stage for it. The challenge here is to build to get the alliances across different regional specificities primarily begin a social engagement process and secondly have systems of linkages between hotspots and solutions. The fifth and final challenge for complex dynamic nitrate cycle, it is not always easy to identify a nitrate cycle specially in a reservoir, that is also common to receiving storm water flow and potential effluents that affect the nitrate sequestration, re-mineralization, in the complex dynamic of the cycle contained in a reservoir on which 5 million people depend.

Contribution of science:

The limitation of science is largely the lack of data in these specific areas leading to a complete lacuna of any available statistic that can lead to effective policy or even begin dialogues on containing an emerging and critical crisis. In the first instance there is lack of micro-plastic data that allows the beginning of a conversation and limiting the degradation of micro-plastics in surface water areas. In the next instance even though there was a very large cache of data spread over a very large number of monitoring stations and a large-scale region, a hierarchical cluster analysis led to specific efficiencies, in the efficiencies, asymmetries of information, that could make the system more efficient for effective water management. In the third instance a spatial mapping of Indian catchment areas and a tenfold cross validation performed across 90+ percent of the catchment areas including water quality assessment indicators led to effective grouping of water quality indices with catchment characteristics and outcomes. In the fourth instance, specific use cases of the Africa models including alliances and consortium is built to both upscale and cross examine specific data show the need for close linkages between on the ground data generation systems directly from the field and information that is generated from orbital mapping of entire regions. This is only possible through extensive collaborative models designed to cross connect widely divergent work. In the fifth instance a complex nitrate dynamic was exposed to look at the function of nitrates and its actual potential contamination characteristics, how sequestration systems work throughout the year with fluctuating nitrate content that is simultaneously connected to storm surges but also to effluent and pollutant movements denote that pollutants are complex and variable with time and space and specific psychical patterns have to be identified to understand the movement of these vectors.

The limitations of the current scientific models in addressing these challenges could be scaling this kind of diverse work and connecting to global applications while simultaneously retaining the specificities generated by that work. The major innovations of the session focus on the large gaps and lacuna that are there both in science and offer enormous potential for cross application not only in different fields but in different regions.

23. Groundwater Assessment and Agriculture

Challenges:

The major water challenges addressed in the session was the availability and access to water resources in different parts of India. Quality of water was also discussed as one of the challenges as water quality is not uniform throughout India and the presenters' study regions. The scale at which these challenges exist are enormous. One speaker informed the audience that the entire Berambadi study area has depleting water reserves due to overexploitation of groundwater. The area covered by the watershed is 100 square kilometres. Furthermore, another speaker stated that 33% of the population in Rajasthan's industrial corridor does not have access to quality groundwater for drinking purposes.

Contribution of Science:

The current scientific techniques being applied are only reporting the changes that are happening in the areas of interest. All the speakers in this session have used GIS and other techniques only to study a problem and report it to the world. The benefits of science have not been used to overcome groundwater issues through proper management techniques.

Limitations of Science:

The main limitation of scientific methods used here is that it is mainly a reporting tool to make people aware of a problem but is not being used to solve a problem. The capabilities of science are not being used to provide solutions that can be implemented to solve the problem.

24. Solutions to Promote Sustainability in Water Space

Susmita Mohapatra: Viable innovative methods for sustainable water future

This study focuses on treating polluted water for domestic use using adsorptive sand filtration process. It tries to solve the problem of water wastage by recycling it through this filtration process, which is claimed to be cheap and innovative. This study uses drumstick (Moringa oleifera) seeds powder and sand mixture to do the filtration process. Cationic anti-microbial protein is claimed to be used as the coagulant to reduce the water turbidity. It is claimed to be able to reduce the turbidity of wells. It is also claimed to be effective for reducing harmful bacteria and thus epidemic intensity. More study is recommended to find the possibility of its usage in ground water remediation.

Monica Sogani: Microbial Electrochemical Remediation System for removal of bioactive compounds from Wastewater

This study aims at devising an efficient and novel technique for wastewater treatment, particularly focusing on estrogenic pollution, and can produce fuel during the process. Synthetic 17-α-ethinylestradiol (EE2) excreted in the urine by humans is mainly used

in female oral contraceptives and possesses more potentially estrogenic effects in comparison with counterparts in natural steroid oestrogens even at low concentration. The steroid's estrogenic potency, in combination with its environmental persistence represents a potential risk to aquatic organisms and humans. A microbial fuel cell(MFC) that uses Rhodopseudomonas palustris microbe is demonstrated. This kind of MFCs are already in use , but this is a bit modified for this particular purpose. Using this cell, it is claimed that EE2 compound can be effectively reduced from wastewater , and during this degradation of EE2 by the microbe , this MFC can produce more hydrogen than when it operates without EE2. So, this focuses on a novel method of treating water affected by EE2 , in addition this method can produce hydrogen efficiently. It is done in lab setup, but further studies for optimization of the degradation process is recommended to scale it up to use this method in wastewater plants.

Baskaran V.: Experimental Study on Domestic Solar Still Desalination with Cotton Gauze –An Approach to Field Model

This study focuses on a domestic method for desalinating brine water. Water scarcity is a major challenge in parts of South India . This study aims at solving that problem in a South Indian coastal city Pondicherry(This study is location specific, as it depends on Solar insolation) . Conventional method of desalination is costly, so it tries to device a low-cost method. A conventional solar still with an extra cotton gauze is demonstrated. It claims to increase the yield of freshwater significantly. So, this is claimed to be a cheaper and efficient method of desalinating brine water. This yield is location specific and condition specific , high insolation is necessary for good yield.

Anamitra Saha: Influence of aridity in the basin characteristics in the Budyko framework: A case study in the Ganga river basin.

This study tries to study various parameters affecting the aridity index under the Budyko framework. Understanding the relationship between climatic variable and river basin-scale hydrology in changing climate is crucial for policy making and adopting adaptation and mitigation strategies. This study tries to test some of the traditional assumption regarding this in Ganga and Damodar basin. Using climate models and feeding the data to hydrological model by statistical downscaling , this study challenges the traditional assumption that basin characteristics parameters are independent of aridity index . It claims that the basin characteristics parameter doesn't represent the basin characteristics solely; it is influenced by the climatic variables as well. This study points out few limitations of current understanding and calls for further research in this area.

25. Technology-based Solutions in Addressing Water Quality

Summary:

This session saw a variety of inputs starting from the development of a low-cost nitrate sensing system that can non-destructively and continuously monitor the quality of water. One can view real time on a mobile phone, this is a critical input that this scalable and deployable across the world especially regions that are flood hit and do not have the scientific systems and techniques for instant water quality assessments. The second input looked at the elimination of emerging contaminants in a multi-barrier water treatment system. Water treatment systems are primarily focused on ozonation as a mechanism to complement the desire for urban water of desired quality. The objective was to identify specific barrier protocols and develop a classification system for chemicals in line with the classification system for microbials. The multi-barrier water treatment system is certainly an innovation to consider the global application in urban settings where water quality availability is a significant concern. The third intervention was an assessment of water contamination using novel techniques based on nanoparticles and bio receptors which works out to far cheaper and far faster in the detection of heavy metals allowing for faster response times in the containment of heavy metal pollution in aqueous media. The fourth presentation looked at Rainwater harvesting and containment of rainwater for non-potable use at school in Berambadi, India.

Challenges:

The first presentation post critical challenges that were rather promising in application, a low-cost sensor for detection of nitrates which is an odourless, colourless substance but in larger doses highly poisonous is a very critical intervention, it is further learned that not only is the system potable low-cost and easily deployable in the field, but can be adapted and modified to a smaller sensor, with a more efficient detection capability that covers, currently theoretically, other contaminants and pollutants. Most effectively this output is instantaneously or near instantaneously available on a mobile phone making this very complex scientific technique highly simplified and accessible to a common person affected in the disaster area and without access to clean and safe drinking water. The second challenge that was noticed focused on a complex barrier elimination system of urban contaminants that includes both effluents and bacteriological profiles. Whereas pathogens are classified and have a system of complex classification chemicals on the other hand have no clear classification system so for chemical classification in a multi-barrier water treatment system mechanisms are used to classify in relation to ozonation as such the four categories of chemicals were divided respectively into their reactions to ozone. This is especially critical where in wastewater across the world have never seen less than 80 chemicals in a sample. The effective removal in the multistage 7 tier barrier is therefore a scalable model that is critically required across the world especially because the condition of water in urban settings are always linked to pollution and quality. The third challenge was especially interesting for providing a unique way of using nanoparticles and

bioreceptors in combination to detect heavy metals in any aqueous media. The proposition of a low-cost detection system that can be deployed fast for quick results is highly desirable and scalable across the world especially in the developing world where testing mechanisms are limited by the energy and cost barrier. The final challenge was effectively implementing a rainwater harvesting system for non-potable water in a village school setting where effective chlorination was maintained to bring the water to WHO standard for non-potable use.

Contribution of science:

The identification of particular frequencies at which certain contaminants can be detected and its application in the sensor that can be easily fabricated in a low-cost setting and a highly portable device with an output that can be rendered into a mobile phone and readable by anyone. This is intervention that will make significant changes to flood affected areas, to disaster hit areas, to water scarce areas and has applicable potential that is global it is critical that these kind of studies are not only funded better but also provided a global stage to reach the right kind of intergovernmental systems that can scale and deploy these technologies for instant use to the most affected people. The real-time benefits of a sensor that can detect nitrates and display its output on a phone would be almost real-time sensing, being low-cost and portable, data being instantly available, no skill required in operations, whereas this is designed for only four nitrates it can also be achieved for other pollutants and contaminants. The second session was looking at effective barrier systems classification systems and deploying this in the multistage wastewater treatment system that can address the crisis of water scarcity and simultaneous water quality problem that critically affects urban centres. This is all the true in India where approximately 80% to 95% of wastewater and sewage are untreated and let off into surface water systems critically affecting safe and available water resources. The third session comprises of a complex intermingling of nanoparticles and bio receptors to generate an appropriate assessment of water quality and contamination of heavy metals within a very short timeframe and at lower cost indices than are normally available. The fourth session examined through a relation of rainwater collected from rainwater harvesting system for non-potable use.

New capabilities and innovations:

The most important intervention in this entire session was the low-cost nitrate sensing real-time system using mobile apps, the application for this is rather tremendous and can be scaled from local to global applications it can be linked to monitoring stations it can be expanded to cost-effective testing solutions that require absolutely no scientific skill whatsoever to operate and no knowledge of complex dynamics of pollutants to be able to understand the outputs. The detection levels of nitrate in the primary focus of this innovation but it can be scaled and applied to almost any contaminant only dependent on the specific frequencies and detection levels those are at present theoretical models. In the second session a multi-barrier wastewater treatment plant primarily depending on ozonation to remove not only pathogens for which there is a complex classification system but also chemicals which needed the development of a new classification system based on mechanisms of

interaction with ozone. Thus, it is a scalable and critical intervention that can address urban water crisis and provide immediate solutions to problems plaguing the Indian terrain. Finally, the last presentation focused on chlorination of rainwater collected through rainwater harvesting system to provide water throughout the year to a village school.

Fig 24: Random sessions in progress.

XI. High Level Panel Discussion Report by Integrated Mountain Initiative

Meeting Summary:

High Panel Discussion: Parliamentarians/ Legislators Dialogue on Water Policy for IHR, Water Future Conference

Date: 25/09/2019

Location: Hotel Sheraton Grand, Bengaluru, India

Time: 11:30am - 1:30pm

Chair: P. D. Rai

Convenor: Integrated Mountain Initiative (IMI) and Divecha Centre for Climate Change (DCCC)

Sponsors: Divecha Centre for Climate Change and Swiss Development Corporation.

Attendees: 14 members
A. MP-MLA's: Ten (10) Member of Parliaments (MPs') and Members of Legislative Assembly (MLA) from Indian Himalayan States (Refer List 1 to 10 – Table 1);
B. IMI: P. D Rai, Chairman and Mr Sushil Ramola, President, IMI.
C. DCCC: Prof S.K Satheesh
D. Swiss Development Corporation: Ms. Maitree Dasgupta, Head of University Partnerships, SWUSSNEX India, Consulate General of Switzerland (Representing SDC)
E. IMI and DCCC Coordinators and Convenors: Golan and P Baisnab (IMI), Anupama Nair and Smriti Basnett (DCCC).

Other Observers (Annex A):
I. Senior Government Representatives: Six bureaucrats from the Indian Himalayan Region
II. Seven IMI Councillors and Members
III. IMI and DCCC Coordinators and Convenors:

Table 1. List of Participants in the High Panel Discussion:

Sl. No.	Name	Designation	State
1	Pu C Lalrosanga	MP (Lok Sabha)	Mizoram
2	Shri Pradeep Tamta	MP (RS)	Himachal Pradesh
3	Ms Agatha Sangma	MP (Lok Sabha)	Meghalaya
4	Shri Chau Zingnu	MLA	Arunachal Pradesh
5	Shri Wangki Lowang	Minister, PHED	Arunachal Pradesh
6	Shri Mmhonlumo Kikon	MLA, Adviser, Science and Technology	Nagaland
7	Shri Sharingain Longkumer	Dy Speaker	Nagaland
8	Smt Ferlin Sangma	MLA, Chairperson, Meghalaya State Council on Climate Change and Sustainable Development	Meghalaya
9	Shri HM Shangpliang	MLA	Meghalaya
10	Shri Rigzin Spalbar	Former CEC, Ladakh Autonomous District Council	Ladakh
11	Prof S.K Satheesh	Chair, DCCC	IISC, Bengaluru
12	Ms. Maitree Dasgupta	Head of University Partnerships, SWUSSNEX India, Consulate General of Switzerland	(Representing Swiss Agency for Development and Cooperation (SDC)).
13	Mr P. D Rai	Former MP- Sikkim, Convenor and Chairman	Member, IMI
14	Mr Sushil Ramola	President IMI	Member, IMI

Table 2. Meeting Agenda:

Sep 25, 2019	High Panel Discussion I: Parliamentarians/ Legislators Dialogue on Water Policy for IHR
	Chair: Shri PD Rai, Councillor, IMI and Former MP (Lok Sabha)
10:00 – 10:05	Introduction: Chair
10:05 – 10:15	Context Setting: SDC
10:15 – 11:00	Panel Discussion: MPs/MLAs, led by Chair. Themes of discussion •Applicability of current national water policies to IHR •Climate change and evolving water problems in IHR •Embedding SDGs in formulation of water policies
11:00 – 11:10	Concluding remarks by Special Guests

Summary of the meeting:

Fig 25: Attendees of the Ministers and MLAs meet held on 25 Sep 2019 at Hotel Sheraton Grand, Bengaluru.

About a dozen MPs/State Ministers and MLAs from the different hill states of the Indian Himalayan Region participated at the High Panel Parliamentarians/ Legislators Dialogue on Water Policy for the Indian Himalayan Region held on 25 September 2019 at the ongoing Water Future Conference: Towards a Sustainable Water Future, Bengaluru. It was organized by Integrated Mountain Initiative (IMI) and supported by Divecha Centre for Climate Change at the Indian Institute of Science and Indian Himalayas Climate Adaptation Programme (IHCAP).

IHR is reeling under climate stress. It is in a state of dichotomy as climate crisis will reduce the value of services provided by IHR to the entire nation. The recent High Panel Parliamentarians/ Legislators Dialogue at the Water Future Conference held in Bengaluru organized by Integrated Mountain Initiative (IMI) supported by Divecha Centre for Climate Change (IISc) and IHCAP raised this dichotomy with a special focus on the increasing water security challenge in the country.

The high level roundtable conference was attended by MPs, MLAs and representatives from Uttarakhand, Ladakh, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Meghalaya and members of IMI, World Bank, Divecha Centre for Climate Change, United Nations University (UNU) and officials from national and international institutes of excellence including Future Earth and Global Water Futures.

The members raised several critical

areas of concern with regard to water source, water quality, management, increasing water scarcity and rapid decline in freshwater biodiversity. Two critical areas of melting of glaciers and reviving springs were discussed at length as is the impact of tourism sector in increasing water stress in the region.

Hon'ble Member of Parliament from Tura and member, Parliamentary Standing Committee for Water Resources, Ms Agatha Sangma highlighted the rising conflicts due to scarcity of water in many rainfed areas. She urged for reduction in ecological footprints and for polluting companies to take responsibility for the mess they have created. States like Meghalaya and Nagaland have recently formulated their State Water Policies, Arunachal Pradesh has the Catchment Area Protection Policy and Water Resources Authority Bill but not an integrated Water Policy.

IHR is witnessing an average of 100 million tourists every year which is set to only grow in the coming years putting huge stress on its carrying capacity. To exemplify this stress, the Ladakh Ecological Development Group's assessment shows that the average use of water by a local resident in Ladakh is 25 litres per day whereas each tourist consumes 75 litres per day. The number is significant for a place like Ladakh which is a water deficit area and is mostly dependent on snow/glacial melt and Indus river flow. This issue was raised by Mr. Rigzin Spalbar, Ex Chairman Leh Ladakh Autonomous Hill Council.

It is also important to note here that the problems of the Western and Eastern Himalayas are very different. Mr. W. Lowang, Minister from Arunachal Pradesh earnestly showed his willingness to take back the lessons learned by other NE states in formulating their Water Policy. Similarly, Ladakh doesn't have a water policy in place but its traditional wisdom to preserve water is strong. Such knowledge should also be taken into consideration while formulating water policies in the region. Mr. H. Shangpliang MLA Mawsynram said Mawsynram in Meghalaya no longer holds the title of the wettest planet on earth but despite having high rainfall, Meghalaya is facing water deficit issues due to its topography and high run-offs. Similarly, Pu C Lalrosanga, MP from Mizoram brought attention to the fact that the soil typology in Mizoram is very porous leading to huge run-offs due to its less water holding capacity and poorly developed conservation techniques.

MLA Ferlin Sangma from Meghalaya stated that Meghalaya has taken capacity building exercises for the local communities, sensitization programme for legislators and grassroot workers to implement the water policy on ground. Mr. M. Kikon, MLA from Nagaland raised the issue of empowering Water Users Association through clear directives and information sharing to improve monitoring of water usage. Mr. Z. Namchoom, MLA from Arunachal Pradesh mentioned that the state is starting to feel the heat of climate change and have thoughtfully budgeted for spring rejuvenation. Mr. Pradeep Tamta, MP Rajya Sabha rightly raised that the crisis in the IHR is a national crisis and not just of the Indian mountain States.

The discussion highlighted the need for a comprehensive water policy for the states of the Indian Himalayan Region and explored areas of strengthening

research, action and policy directions. Acknowledging the need for a sustained, integrated effort to addressing key water issues of the region, a proposal was made to establish a Mountain Solutions Programme which will include a Water Solutions Lab for the region.

The meeting concluded with the chair, Mr PD Rai, former MP (Sikkim), emphasizing the need for more interactive platforms between the scientific community, policymakers and communities to arrive at better solutions in building a water secure future. To take forward the concerns of the Himalayan legislators on this issue, a note was submitted to the Standing committee on Water Resources highlighting the takeaways from the Conference.

Minutes of the Meeting:

Attendee from Swiss Agency for Development and Cooperation - Ms. Maitree Dasgupta:

- Short description of the kind of water-related issues faced in the Himalayan region, including dependence on natural springs, rise in the intensity of rainfall and decline in the number of rainy days, neglect of water management practices and less frequent winter rains.
- Partnerships between SDC and Himalayan and sub-Himalayan states: two climate change adaptation projects--Indian Himalayas Climate Adaptation Programme and strengthening state strategies on climate adaptation.
- Notes that there has been less emphasis on demand side management of water, adaptation, and the revival of springs. Also points out the need for management of glacial hazards and risks, and glacial lake outbursts and floods. SDC has current partnerships with National Disaster Management Authority, with whom they would like to work on these things.

Fig 26: High panel discussions in progress during the Ministers and MLAs meet.

Mr. P. D. Rai:

He called for attendees to talk about the challenges that people face in the Indian Himalayan region and their respective states.

Shri. Wangki Lowang, Minister, PHED:

- Draws out a brief description of the geography of Arunachal Pradesh, the higher part of which gets water from snow-fed rivers and the lower part from rain-fed rivers. Observes a slow increase in seasonal temperature over the years and notes that previously perennial streams now dry up during the winter, resulting in a search for alternative sources of water supply.
- Arunachal Pradesh is trying to make policies for catchment protection. Speaker points out that any state programme being limited to only one department cannot do enough and calls for programmes by the central government to follow a multi-thronged approach since it is not suitable to apply common solutions in different areas.
- Emphasises on the persistence of jhum cultivation in the state, which he would like different state departments to jointly address and push for mountain terrace wet rice cultivation as an appropriate alternative to shifting agriculture.

Shri. Sharingain Longkumer, Dy Speaker, Nagaland:

- Warns about the urgency of the impending global crises owing to climate change that will occur over the next two to three decades. Points to an expected mass migration of people due to limitation of resources, especially water.
- Asks how the Northeast region can help solve India's water crisis--how can water be transported from the water-rich parts of the region to the rest of India?
- Gives the example of Sikkim, which has taken the following steps to improve water management: (1) identification of spring water and proposed places for intervention, (2) figuring out what needs to be done to supplement or replenish spring water in selected location, (3) figure out how to coordinate so that water is used in the right way for maximum sufficiency within the state, and send excess to other places in the country that face water scarcity and contamination.
- Urges all mountain states in the Northeast to come together to make water policies with collective objectives.

Pu. C. Lalrosanga, MP (Lok Sabha), Mizoram:

- Questions the need to ask the government for more water supply in spite of receiving high amounts of rainfall; why is water during the rainy season going to waste? Points out the need to harvest and store rainwater.
- Points to the lack of provisions for making better use of water resources and highlights the need for better water management systems.
- Calls for state water policies to be aligned with national policies, while focusing on mountain springs since groundwater is not a dependable source in areas with high levels of surface water run-off.

Ms. Agatha Sangma, MP (Lok Sabha), Meghalaya:

- Speaks about the private ownership of ring wells controlled by different political parties in her constituency, pointing to the already worrisome condition of water availability and access.

Fig 27: One of the participants presenting during the Ministers and MLAs meet.

- Acknowledges the Jalashakti ministry for having recognised water as a global crisis.
- Points out that Meghalaya is the first state in the Northeast to have its own water policy and calls for other states to follow suite.
- Emphasises on the need for different departments to be involved in collective water management.
- Calls for the need to shift to organic agriculture since chemical fertilizers cause water contamination.
- Calls attention to the importance and relevance of rainwater harvesting, not just for household water supply but also to replenish groundwater and cites Mizoram as a good example of this.
- Also draws attention to ecological footprints as a means to increase accountability of corporations and other organisations that pollute to the public.

Shri H.M. Shangpliang, MLA, Meghalaya:

- Presents a short video on the threat that Mawsynram faces of no longer being the wettest place on Earth and asks what the fate of such places will be in the face of a changing climate.
- Also urges for rainwater harvesting with groundwater recharge mechanisms to be put in place in urban and rural areas, in order to store and harvest some of the rainwater that would otherwise flow to the plains of Bangladesh.
- Speaks of seasonal water shortage and floods, the effects of which are exacerbated by poor management practices. Also alludes to degraded catchment areas resulting in water quality problems that make water importable.
- Would like a forum to be created with legislators from the Northeast and the Indian Himalayan Region to be a part of the policy-making process and help IMI bring development in the IHR.

Smt. Ferlin Sangma, MLA, Chairperson, Meghalaya State Council on Climate Change and Sustainable Development, Meghalaya:

- Also calls for coordination across different state departments for climate action.
- Suggests mainstreaming of climate change adaptation and resilience in livelihoods, state-specific action and capacity building, and to use this as leverage to bring more funds into various programmes.
- Also suggests that there be sensitization programmes of all legislators and intensive and aggressive sensitization of people at the ground level about climate change action, to inform people about where to start.

Shri Chau Zingnu Namchoom, MLA, Arunachal Pradesh:

- Arunachal Pradesh has not had any major water problems until recently, but natural springs and rivers are now drying up.
- Notes that efforts to conserve water cannot succeed without the involvement of communities, especially since the population is low.
- Also supports that the practice of jhum cultivation be done away with and replaced with terrace cultivation.
- Notes that the CM of Arunachal Pradesh has urged all MLAs of the state to plant trees as part of CAMPA.
- Requests attendees to help finance good water policy in Arunachal Pradesh.
- Counters the statement made by Agatha Sangma about organic agriculture, saying that the self-sufficiency of farmers will end if chemical fertilizers are no longer used.

Shri Mmhonlumo Kikon, MLA, Adviser, Science and Technology, Nagaland

- Announces that a new system has been in approved this year in Nagaland wherein all agricultural departments are to help draft Nagaland's water policy.
- States that sufficient attention is being paid to spring sheds in the state. According to policy, one spring shed is selected in every two districts for recharging efforts.
- Also announces that an MoU has been signed with the rural department to divert MGNREGA funds to recharge springs in every village and suggests this as a solution to the lack of funds. Acknowledges Peoples Science Institute and ACWADAM for their contribution to this.
- Recommends more workshops to be organised to strengthen training, support and develop the capacity of the community, and also that end users be involved from the beginning and not treated just as end users.
- Says that there has always been an attempt to create an integrated water policy, but every minister faces their own unique challenges. Water scarcity issues are seen as separate when they are related to other things like food security.

Shri Pradeep Tamta, MP (RS), Himachal Pradesh:

- Observes that the water resources of the IHR are not only of the IHR but of much more of India (including Uttar Pradesh, West Bengal).
- Urges the need to prioritise water allotment and usage. Suggests that the government of India must decide and prioritise water for drinking purposes and for agriculture and reconsider the

amount of water allotted to hydropower projects since these cause problems in surrounding areas.

- Points that drinking water and irrigation continue to be big problems and that the government is not helping with infrastructure to facilitate water usage in rural areas.
- Suggests a shift in energy source from hydropower to solar, and a shift towards agriculture that uses less water.
- Says that problems of the IHR must be taken up by the central government, especially since the Himalayan region is very big and spread across various borders, and that state revenues can be diverted for this cause.
- Observes that while the Indian government takes an active stand for the people when they act against the construction of large hydropower projects in other countries, it takes quite the opposite stand and is against the people when this happens in India.

Prof S. K. Satheesh, Chairman DCCC

- Notes that there are many common problems faced by most states in the IHR, especially agriculture and water.
- Points that glaciers and rainfall are two factors closely related to agriculture out of which the former is easy to study and make recommendations about, but the latter is difficult to study and model.
- Notes that electricity and air are also two things that are important to discuss in such a context.
- Recommends the preparation of an assessment report to come up with solutions for various issues and put forth appropriate recommendations.

Fig 28: Prof. S. K. Satheesh talking during the Ministers and MLAs meet.

Shri Rigzin Spalbar, Former CEC, Ladakh Autonomous District Council

- Emphasises the need to consider traditional wisdom of water management.
- States that the area faces acute water shortage during the winter and that glaciers have started receding, resulting in less sources of water.
- Also points that the rivers from Ladakh flow through the lowest parts of the valley which are in Pakistan.
- Observes that policies made in Delhi and Srinagar have failed in Ladakh and hopes for the making of policies that are more specific to the union territory.

Mr Sushil Ramola, President IMI

- Suggests that supply and demand side water management be made more state-specific, in order to make policies more holistic.
- Would like the IMI to bring in advocacy in the IHR and make state legislations give more recognition to environmental problems and make common problems faced by different states easier to deal with.
- Calls for capacity building to start either at school level of college level. Announces that the IMI is finalising an MoU with Divecha Centre for Climate Change to transfer our knowledge and work to students.
- Suggests that a forum be created today, of parliamentarians and state legislators, who will constantly work on the issues discussed today and across all domains and stakeholders.

Mr. P. D. Rai, Chairperson

- Closing remarks including a thank you to all attendees.
- Ends meeting by noting that there are many students presenting their work on glaciers in the IHR during the conference, almost none of whom belong to the IHR. Would like to see more students from the IHR to work on these problems and share their work during such conferences.

Fig 29: Mr. P.D. Rai addressing the attendees of the Ministers and MLAs meet.

Annex:

I. Invited Guests – Five Government Bureaucrats:

Sl. No.	Name	Designation
1	Tony Marak, IFoS (Retd)	Chairman- State Environment Impact Assessment Aut.-Meghalaya. Former PCCF, Meghalaya Former PCCF, Meghalaya
2	Prof Lalnuntlunga	COE, Mizoram University, Vice President, MSDF
3	Aiban Swer	Director, MBDA, Govt of Meghalaya
4	Dr Pankaj Barua	Director, NERIWALM, Ministry of Jal Shakti
5	Shri Dhiren Shrestha	Director, Science and Technology, Govt. of Sikkim

II. Integrated Mountain Initiative (IMI) Councillors:

Sl. No.	Name	Designation
1	Mr Ramesh Negi, IAS (Retd.)	Vice President IMI
2	Dr Lalbiakmawia Ngente	Vice President IMI
3	Ms Fantry Mein Jaswal, IRS (Retd.)	Secretary IMI
4	Mr Alemtemshi Jamir, IAS (Retd.)	Councillor, IMI
5	Dr Vincent Darlong	Councillor, IMI
6	Egam Basar	Sustainable Development Forum of Arunachal Pradesh

II. IMI and DCCC Coordinators – Four Members:

Sl. No.	Name	Designation
1	Golan Naulak	Programme Coordinator
2	P Baisnab	Programme Coordinator/ Rapporteur
3	Smriti Basnett	Convenor and Facilitator
4	Anupama Nair	Rapporteur

List of MPs, MLAs'

1. Pu C Lalrosanga, MP (Lok Sabha), Mizoram. 2. Shri Pradeep Tamta, MP (RS), Himachal Pradesh. 3. Ms Agatha Sangma, MP (Lok Sabha), Meghalaya. 4. Shri Chau Zingnu Namchoom, MLA, Arunachal Pradesh. 5. Shri Wangki Lowang, Minister, PHED, Arunachal Pradesh. 6. Shri Mmhonlumo Kikon, MLA, Adviser, Science and Technology, Nagaland. 7. Shri Sharingain Longkumer, Dy Speaker, Nagaland. 8. Smt Ferlin Sangma, MLA, Meghalaya. 9. Shri HM Shangpliang, MLA, Meghalaya. 10. Shri Rigzin Spalbar, Ladakh Autonomous District Council, Ladakh.

XII. Abstracts from Special and Parallel Sessions

Contents:

1. Special Session: Water Solutions for the 21st century in the Indian Himalayan Region and Climate Impacts on Global Mountain Water Security

i. Decentralized Water Governance Model in the Central Himalayan Region of India

Vinod kothari, S.T.S. Lepcha and Sunesh Sharma

In Indian Himalayan Region (IHR) Water governance evolves around the "springs" and act as lifeline. In Uttarakhand more than 94% rural water supply is driven through spring fed systems. About 71% of the State's geographical area is categorized as forest cover and mostly the recharge zones of springs are located in forest areas. The state forest department is also undertaking measures for groundwater recharge, under its watershed approach. However, to optimize the results it needed a scientific approach for aquifer mapping and dedicated long term planning and management on spring-shed/catchment. Considering the importance of springs in IHR, NITI Aayog has constituted a working group on "Inventory and revival of springs of Himalaya for Water Security", and report presented to government of India.

Uttarakhand Forest department has proactively referred NITI Aayog's recommendations on spring's management and constituted a Spring-shed Management Consortium (SMC). The SMC is headed by the Principal Chief Conservator of Forests (PCCF), Uttarakhand. The consortium has 18 members which included civil society organizations, line department and experts. Himmotthan Society is Member Secretary and responsible for taking forward the SMC objective in a planned manner and working for a state-wide Springshed management programme.

Overall idea is to build capacity at the Panchayat Level, as they are the real custodian of natural resources which included water. Integrated efforts of all line department and civil society will ensure water governance system more robust. A few important protocol need to be incorporated at the Panchayat level which included (i) an inventory and regular data of village water resources and its management plan; (ii) Detail mapping of springs in reserve forest areas and recharge plan; (iii) A specific fund allocation on water management and its regular monitoring would provide strength to village economy, whilst ecosystem services at large, thus improving the quality of lives Himalayan communities.

ii. Vulnerable Smaller Water Resources: evidence of diminishing discharge of spring-flow, declining trends of monsoon rainfall and recent land use changes in Mid-Himalayan Mountain, India.

Soukhin Tarafdara, G.B. Pant National Institute of Himalayan Environment &

Sustainable Development, and Subhashis Duttab, Department of Civil Engineering, IIT Guwahati

The Indian Himalayan Region is at the cross-roads where major anthropogenic drivers such as damming, road-cutting and land use change are severely impacting the natural flow regimes of not only the large rivers but also the interlinked smaller springs and streams. Additionally, declining trend of monsoonal rainfall between 1965-1980 periods is reported from most populated mountain region of lesser Himalayan in Uttarakhand (Basistha et al., 2009).

Water availability for headwater communities across Himalaya is largely sourced by smaller water resources like springs, seeps or wet-weather springs and streams. Threat to these key resources will have a cascading effect on vulnerable communities, their livelihood and several interdependent ecosystems. Results are presented from detailed study in two headwater catchments from water-scares region of Pauri district, Uttarakhand, India.

The precipitation variability of Indian summer monsoon during 2009 to 2018 period showed inter-annual variability with drought, intermittent multiple deficient rainfall period and normal monsoon rainfall years. Analysis of long-term records of spring-flow through flow duration curve indicate a significant reduction in low flows as well as during high flow periods. The land use change analysis highlights that over a period of nine years the area under the pine forest has increased by (+) 40% whereas, the agricultural land has reduced by (-) 48%. The interlinks between the spring, seeps and low-order stream is deciphered through electrical conductivity, temperature and stable isotope measurements.

iii. Climate change vulnerabilities of rapidly growing cities in the Himalaya and policy interventions for mitigation with special reference to Gangtok and the Teesta river basin

P. D. Rai and Rajendra P. Gurung

Climate change induced global warming is resulting in glacial melt in the Eastern Himalaya at an unprecedented rate. The retreating glaciers, formation of glacial lakes and outburst floods are a major cause of concern. The Teesta river originates from the glaciers in the Eastern Himalaya and drains through Sikkim into West Bengal. This paper will examine the vulnerabilities and hazards from the phenomena of climate change, changes in snow and glacier runoff and frequent cloud bursts. The main source of water supply for Sikkim's capital Gangtok comes from glacial melt, monsoon and winter rains and the underground water systems which form springs dotting the landscape. How are all these impacting the water security for Gangtok in view of a rapidly growing urban population is a question of worry. This paper will discuss the political economy of water distribution which adds to vulnerabilities. The paper will present policy interventions to mitigate water security and recommend measures to mitigate the impact of climate change on people living in the basin.

iv. Conservation planning in human dominated riverscapes: case study of Ganga

Michelle Irengbam; Shivani Barthwal, Niladri Dasgupta, Ruchi Badola & Syed Ainul Hussain

Conservation of freshwater systems has remained peripheral to terrestrial conservation planning, resulting in poor conservation and degradation of these ecosystems. For rivers, conservation planning is complicated by their connected nature, non-feasibility to conserve entire rivers and non-inclusivity of habitat features. Economic and social constraints in human dominated basins further complicates planning. Considering these issues and taking the Ganga as our subject, we adopted a multistage systemic approach to outline river conservation strategies and derived the most feasible approach in the context of human dominated river basins. Additionally, Indian policies were reviewed to identify underlying issues hindering river conservation. These include the commercial focus of policies, nescience of river connectivity and lack of protection of rivers that are prime habitats for several rare and endangered species. Strategic prioritization and zonation of rivers to set aside "optimal sites" for focal species and areas under multiple management zones is recommended.

v. Seasonal water quality variations of palustrine wetland of Barrack-Chindwin basin

Chongpi Tuboi, Michelle Irengbam, Ruchi Badola, Syed Ainul Hussain; Wildlife Institute of India

The Loktak Lake is a palustrine wetland located in the Barak-Chindwin river basin of Northeast India. The Lake is known for its characteristic floating meadows, locally known as phumdis. The southern part of the Lake is protected as the Keibul Lamjao National Park as the last remaining habitat of the Eld's deer in India. We examined the seasonal pattern of water quality to improve conservation measures. Significant difference in terms of water quality parameters were observed across different parts of the lake and seasons (ANOVA, $p<0.05$). Principal Component Analysis identified three factors which explained 92.9% of the total variance of the data set. Our study revealed that the Lake is hypereutrophic that has adverse impacts on ecosystem level processes. Restoration of the Lake requires an integrated approach in reduction of nutrient inputs, enhanced flushing mechanism and restoration of environmental flow which has been disrupted due to damming.

vi. A need for Integrated Urban Water Security in the hill towns of Darjeeling, Himalayas, India

Lakpa Tamang, University of Calcutta

The study is an attempt to understand the aspects of water security encountering the issues of water crisis in the hill towns of eastern Himalaya. An in-depth study of different parameters that govern the

nature and scenario of present-day water security in Darjeeling town have been undertaken through a rigorous field study during 2017-18. It is observed that owing to a mountainous landscape, the town is not suitable for large-scale extraction of surface and ground water, and hence is more dependent on the local water sources like natural springs. The centralized public water supply system conveying through the reservoirs situated at distant locations (Sinchel reservior) and the local water sources (natural springs) catering majority of the population are mainly incorporated for assessing the different parameters affecting the water security in the town.

2. Assessing Sustainability in Water Space

i. Assessment of surface water storage trends for increasing groundwater areas in India

Chandan Banerjee, Water Solutions Lab

Recent studies suggest that groundwater has increased in central and southern parts of India. However, surface water which also contributes towards the sustainability of water resources in these semi-arid areas has not been studied yet. In the present study, Surface Water Extent (SWE) and Surface Soil Moisture (SSM) were selected as proxies of surface water storage. Granger-causality test is used to test the hypothesis that rainfall is a causal factor of the inter-annual variability of SWE, SSM and TWS.

ii. Future dynamics of development, climate impacts and water resources adaptation

Peter Conway, University of Leeds

In the Lake Malawi Shire River Basin (LMSRB), Lake Malawi outflows sustain hydropower, irrigation, urban water supply and flow requirements for a Ramsar wetland. In the early 20th century, lake levels dropped below the outflow threshold. Such an event poses risks to Malawi's future sustainable development. The study develops a stakeholder-informed water resources model for the LMSRB to (a) examine the potential impact of climate change and socioeconomic development on future lake levels (b) assess risks to existing and proposed downstream infrastructure from lake levels dropping below the outflow threshold (c) assess the ability of water management options to address potential future risks. Addressing calls for model-coproduction the study iteratively engages stakeholders to collect data, insights and priorities to inform the development of a Water Evaluation And Planning (WEAP) model for the Lake Malawi Shire River Basin.

iii. Agriculture and safe operating space: A global analysis

Ajishnu Roy, Presidency University

Agriculture plays important role in exceeding planetary boundaries mostly in Africa, Oceania, Asia and South America. In some of the dimensions, condition is improving gradually. But to be sustainable, biophysical resource consumption and emission should be improved significantly. There can be three main driving forces behind planetary boundaries - agriculture, industry and household consumption. The study calculates how much agriculture is globally responsible for exceeding planetary boundaries.

iv. Assessment of Multiple Modeling Approaches to Address the Quest for Physically Realistic Hydrologic Models
Ashlin Alexander, Indian Institute of Science

This work aims at developing a flexible framework that helps to identify the apt model structure or set of feasible model structures for the study catchment. This so identified model structure or structures would enable to model the dominant hydrological and biophysical processes for the study area. This work is undertaken from the motivation to develop a focused place-based model rather than using a prior model and fitting it to the catchment under study. The work aims to provide an insight on how to systematically implement and evaluate alternative modelling approaches for process representation. This systematic model analysis helps to understand the reasons for inter-model differences in model behaviour. It helps to gain insight on dominant physical processes when applied across different catchments.

v. Multi-site and multi-variable hydrological model calibration for spatially heterogeneous catchments
Saumya Srivastava, Indian Institute of Science

Hydrological modelling is an indispensable tool for watershed simulation in water resources planning and management. Model calibration, validation, parameter sensitivity and uncertainty analysis are essential prior to the application of hydrological models. Various methodologies have been devised to perform the above procedures in an efficient manner. The current study compares the performance of these methodologies for the spatially heterogeneous catchment of the Mahanadi basin in India.

Fig 30: Session on Assessing Sustainability in Water Space in progress.

3. Groundwater Assessment and Analytics

i. Spatial-temporal groundwater trend analysis: Case study of India

Bankaru-Swamy Soundharajan, Amrita Vishwa Vidyapeetham

In this study we have focused on the comprehensive analysis of long-term groundwater layout and trends using the observation well data collected over 22 years (1996 to 2017). Groundwater level data were collected from about 25,000 locations across India at pre-monsoon, monsoon, post-monsoon (Kharif) and post-monsoon (Rabi) and has been categorised into seven groundwater regimes, spatially. The objectives are to understand the groundwater fluctuations (spatio-temporal) at annual to decadal scale and identify the trends in groundwater level (i.e. increasing, no change and decreasing) at various regions. This study will aid in identifying the hotspots of rapidly depleting areas for possible groundwater management measures.

ii. Groundwater assessment at local scales: BIG DATA and policy implications

Prasanna Sampath, IIT Tirupati

FAO predicts that agricultural output will almost double by 2050 to address global demands. While global resources are enough to meet this increase, the "devil is local" given the alarming depletion in groundwater resources at local scales and uncertainties in rainfall due to climate change. A detailed assessment of available groundwater resources at local scales requires information regarding rainfall and crop distribution. Taking advantage of publicly available BIG DATA, this study developed a data-intensive approach for groundwater assessment at high-resolution. The major objective of this study was to estimate groundwater consumption at the local scale that can help policymaking at the "global" level. The approach outlined in the study allows identification of local hotspots that require policy interventions to enhance water levels, improve productivity, and reduce energy costs, thereby tackling the water-energy-food nexus. The learnings from this research will be helpful in fine-tuning policies to local challenges and in creating a bottom-up approach towards sustainable solutions for agriculture.

iii. Groundwater in the hydrological cycle: The known-knowns, the known-unknowns, and the unknown-unknowns

Shaminder Puri, Water Future

Much is known and understood about the prevalence of groundwater on all continents. Despite this knowledge, the governance of this resource is in a very poor state. There is an urgent need to arrive at convergence of the science, the policies and the practices in hydrogeology

Fig 31: Groundwater Assessment and Analytics session in progress.

as a critical part of the hydrological-anthropological ecosystem.

iv. The flow system approach for coping with changing groundwater scenarios

Javier Castro-Larragoitia, Autonomous University of San Luis Potosí

The use of the Tothian groundwater (GW) flow system theory where local, intermediate and regional systems are defined, enables a better understanding of the groundwater functioning. Local systems have relative short travel distances and are the more vulnerable to pollution and climate change. Intermediate and regional flows travel long distances and suffer a stronger change in its characteristics due to the deep circulation and longer interaction times with the geological framework. Thus, a wide system-view analysis of partial evidence represented by surface (soil and vegetation cover) as well as hydraulic, isotopic and chemical groundwater characterization in the related geological media where the depth of actual basement rock is paramount as well as discharge areas is evaluated. The objective of this work is to discuss and show the applicability of GW flow systems theory to asses and propose solutions to GW-management problems.

4. Socio-cultural and Ecological Dimensions of Water Resources Management

i. Hydro-technology in India: stories of disconnections with culture and ecology

Paulina Lopez, Centre de Sciences Humaines

The dominance of a technological approach in water management in India has led to several problems of water quantity, access and quality, and leading to biodiversity, cultural and environmental stresses. This perspective excludes questions of an ecological value of landscapes, the time frames of a natural systems, or interdependences between water biodiversity, population and culture. An innovative approach is needed to achieve sustainable water management planning. The present investigation places the management of water resources in the debate on the Anthropocene suggesting a need for an epistemological shift for the understanding of the space.

ii. The Importance of sand in rivers: the socio-economic and cultural impacts of river degradation

AR Vishnuprasad, Vayali Folklore Group

Rivers has an important role in maintaining the groundwater balance of its own catchment area. Mostly there is a give and take policy between the river and the groundwater aquifers of its catchment. The death of the river is the drain of the groundwater aquifers. The river has to be considered as a single unit from its head to its mouth. The major issues which our rivers are facing are due to anthropogenic activities like sand mining, waste dumping, land encroachment, filling of the watershed etc. These have direct impacts on everything which depends on the river life. One must understand the rivers before planning any action for river management. It should be multidisciplinary approach. The river is not just a stream of water which is just passing by. It has life and lives in it. This study mainly focuses on the socio economic and ecological impacts of the river sand mining.

iii. Threat assessment in Middle Karnali Watershed: sustainable utilization and conservation

Binita Pandey, Resources Himalaya Foundation

Sustainable utilization and conservation of aquatic biodiversity depend on analyzing the factors posing a threat to the aquatic ecosystem. Baseline information on threats to fish biodiversity and socio-economic status of fisher communities were obtained through the questionnaire survey. Fisher folks (n=240 individuals) from five municipalities and rural municipalities were surveyed. The areas are reported to be in higher threat of over-harvesting and destructive fishing practices.

5. Water-Energy-Food Nexus Assessment and Governance

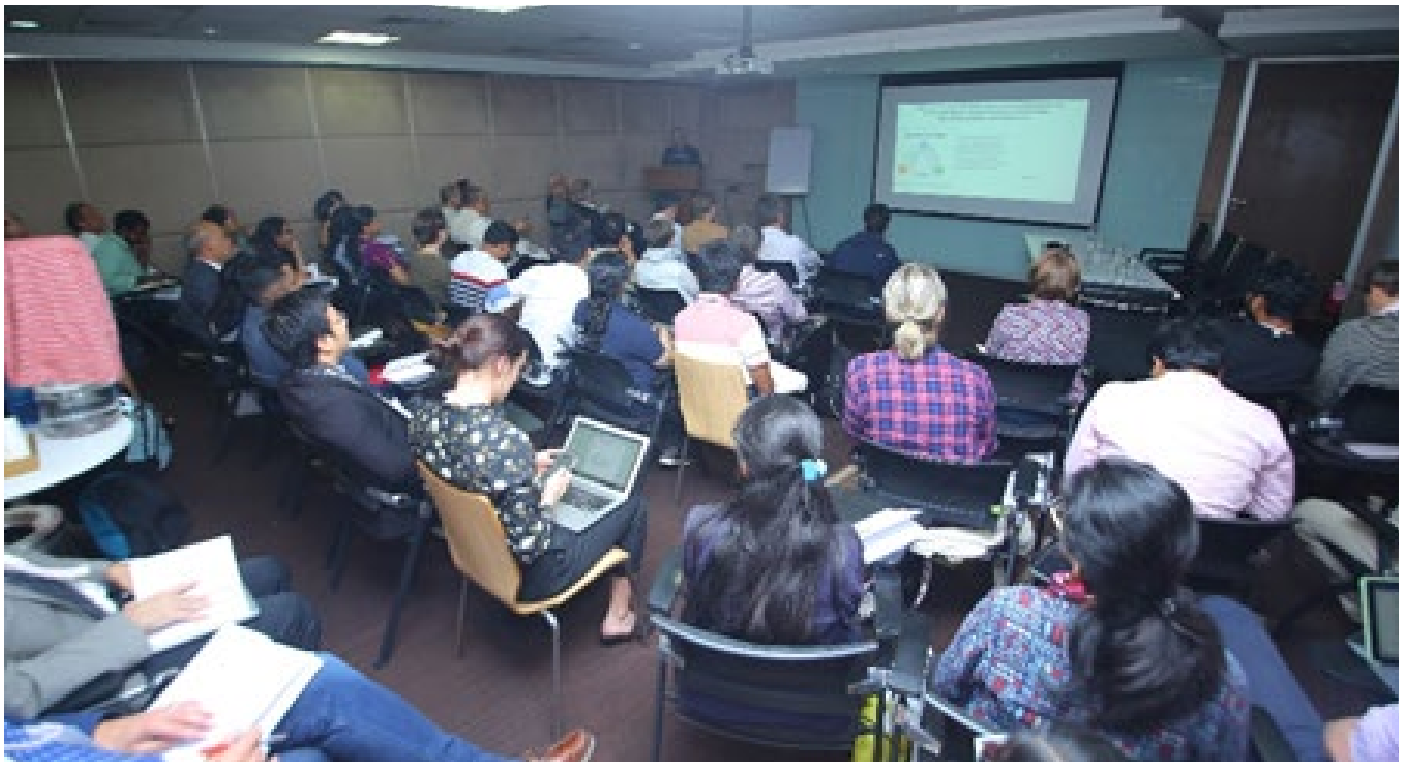


Fig 32: Socio-cultural and Ecological Dimensions of Water Resources Management session in progress.

i. Water quality as an indicator to explore interlinkages between the WEF resources

Martina Floerke, Ruhr University Bochum

Thematic scope: Trade-off analyses around the water-energy-food nexus and implications for the environment With the help of the Water-Energy-Food perspective not only water quality problems can be understood, but more over water quality can be used as an indicator to explore the interlinkages between the WEF resources. This is addressed using two approaches: a conceptual model approach and large-scale water quality modelling. In this paper we have used salinization as an example to mark the synergies and trade-offs between water quality and related WEF resources. We show that high salinity levels lead to a degradation of water quality and thus impact food production, energy production, aquatic ecosystems and sustainable industrial production.

ii. Hydrological impact pathways of drought-related electricity outages in Southern Africa

Declan Conway, Grantham Research Institute, London School of Economics

In situ and remotely sensed time series

of precipitation, river flow and lake levels are complemented by interviews with key informants and a survey about awareness, impacts, and response in businesses in the capital city Lusaka. Results show that drought conditions prevailed in large parts of southern Africa, reducing runoff and contributing to unusually low lake levels in the Kariba reservoir that contributed to unprecedented hydroelectric load shedding across Zambia. This study presents the hydrological response and impact pathway of drought during the 2015/2016 El Niño in the Zambezi basin and its association with power outages in Zambia. The hydrological impacts were severe and complex, exacerbated by dry antecedent conditions, changes in exposure and management decisions. Insights into hydrological responses and the complexity of differing impact pathways can support design of more adaptive management strategies.

iii. The food and water nexus - sustainable irrigation in Africa?

Jamie Pittock, The Australian National University

Irrigation schemes are complex socio-economic systems at the nexus of food and water management. Instead of providing food security, in much of Africa they are failing. We intervened at six schemes in Mozambique, Tanzania and Zimbabwe from 2013 with two farmer-led measures. Simple to use tools, the Chameleon and Full Stop, enabled farmers to measure and manage their own soil fertility and moisture. Our work reframes irrigation schemes as complex socio-ecological systems and posits that multiple, mutually reinforcing interventions are required if land, energy and water are to be used most productively to supply food. We sought to change the incentives for farmers, businesses and governments to make irrigation more sustainable.

6. Lake Quality Assessment and Case Studies

i. Managing dissolved oxygen levels in human dominated ecosystems: a case study of Jakkur Lake, Bengaluru

Priyanka Jamwal, Ashoka Trust for Research in Ecology and the Environment (ATREE)

Jakkur Lake is man-made lake located in the city of Bengaluru, India. The lake receives tertiary treated effluent from constructed wetland and inflows from overland runoff and precipitation. Over the period the nutrients levels in the lake, particularly phosphorous, nitrate and ammonia have increased manifolds. In this work, we evaluated the current condition of Jakkur Lake and recommended the reductions in nutrient loadings required to maintain the in-lake DO levels.

ii. Conserving lake in Bengaluru through environmental placemaking:

inclusive approaches in urban ecology
Amrita Sen, Azim Premji University

In this presentation, we argue how in an era of globalization, multiple forms of individual experiences can be discursively integrated to create a shared sense of place-identity, to conserve the lakes in the city of Bengaluru. To this end, we use the term 'environmental placemaking', to illustrate coproduction of interventions in attempts towards sustaining urban ecological commons like the lakes. It is a qualitative study, conducted through semi-structured and in-depth open-ended interviews conducted across the three lakes in peri urban Bengaluru. The rationale for selecting these lakes is their concurrent associations with both traditional, livelihood and culture-based, and recent, recreation-focused patterns of usage.

iii. Understanding the impact of mining on urban lakes
Shashank Palur, Ashoka Trust for Research in Ecology and the Environment

Bengaluru's lakes have seen a new lease of life with multiple lakes undergoing rejuvenation efforts, primarily by managing the raw sewage flowing into the lake. Although the general motive is aesthetic, there have been social, ecological and hydrological benefits from these activities. Through these activities, lakes have been somewhat restored, except in the terms of water quality. This paper aims to model the flows of the lakes and their interdependence on each other and to model the impacts on Jakkur and its downstream lakes due to diversions to the power plant where they receive partial or no water from the STP.

iv. Effect of lake encroachment and depletion on urban floods in Bangalore
Aisha Sharma, Indian Institute of Science

Urbanization in Bangalore has increased faster than expected in recent decades. Bangalore, once branded as "City of Lakes", is now witnessing the drying of the water bodies due to a rapid increase in the urban areas and anthropogenic contributions to the local environment. The temporal analysis of water bodies indicates a sharp decline of 58% in Greater Bangalore, accompanied by 466% increase in the built-up area from the year 1973 to 2007 (Ramachandra and Mujumdar, 2009). The objective of the study is to analyse changes in lake capacity and depletion and its effects on flood inundation in the Bangalore city.

v. Tropical freshwater lakes of Kerala State, India: Hydrogeochemistry and drinking water potential in Anthropocene perspectives
Aditya K, ESSO-NCESS

The present study has made an attempt to evaluate the various hydrogeochemical properties and determining drinking water potential of three prominent lake systems in Kerala viz. Vellayani, Sasthamkotta and Pookot which are situated in three

geographically distinct locations and to suggest some management measures in Anthropocene perspectives. The present study helps in assessing the water quality of these lakes which helps in benefiting the people who are directly or indirectly using these lakes for their day to day needs.

vi. Water quality status and trends of the world's largest lakes

Laurence Carvalho, Centre for Ecology and Hydrology

Lakes and reservoirs are critical water resources underpinning sustainable development. Data from Earth Observation are now available globally to support monitoring SDG Indicator 6.3.2 (good water quality). We use newly available EO data on chlorophyll status of the world's 1000 largest lakes, combined with data on catchment land use, populations, weather and lake characteristics, to understand the drivers of water quality. The analysis indicates that the sensitivity of the chlorophyll response varies significantly by lake type, especially in relation to latitude, altitude and water depth, with shallower lakes being most sensitive.

vii. Water quality of Oussudu lake in Puducherry - Influence of high turbid run-off

Anjali Deshmukh, Pondicherry College of Engineering

Osudu Lake is a large and shallow wetland which is situated 10 km away from Puducherry. It not only recharges the nearby aquifers, but it is also a home for a large variety of flora and fauna. It hosts about 20,000 migratory birds every year. This study aims at analyzing the water quality of lake, understanding the threats to the lake and suggesting remedial measures. Results obtained suggest that Osudu Lake is moderately polluted and shows a trend of eutrophication in future. Run-off carries wastes from different sources and hence is a major concern. The rainwater samples were taken, and it was slightly acidic in nature. The value of turbidity in Lake Sample, sample of nearby bore-well and tap water clearly explains the presence of run-off in water. Since, lake has a fragile eco-system and cannot undergo self-purification, pollutants can get accumulated easily. Hence, few efforts like diversion for prevention of leaching of nutrients from catchment area through nearby plantations would definitely yield healthy, hygienic and sustainable environment. Barriers can also be provided around the lake such as slurry walls, cut-off walls, and geo-membrane walls for preventing the contaminants from entering the water body. Proper sanitation measures and environmental education to public are essential to keep the water bodies clean and safe.

7. Geogenic Pollutants in Groundwater

i. Water resources and social structure in Arsenic contaminated village in Patna district

Asrarul Jeelani, Centre of Social Medicine and Community Health, Jawaharlal Nehru University

This study attempts to understand the social and health implications of arsenic poisoning in a village of Patna district. The common manifestation of arsenicosis as skin lesions, skin pigmentation, keratosis on palm and sole had been found however rare manifestations were also reported. As water resource utilization, the villagers are using hand pump, dug well and bottled water supplied by a private vendor. The caste variable had also been found. The common manifestation of arsenicosis has increased by 1.3% within six years of span in the village. The physical manifestation on skin has been found in children as well. This raised the need for setting up a proper surveillance system in the village. To minimize the ramifications, dug the community has suggested well utilization.

ii. Arsenic in shallow Bengal aquifer: Large scale human-water interaction and suffering

Debashis Chatterjee, University of Kalyani

Groundwater is contaminated with geogenic As and exceeds WHO guideline value. Groundwater flow is slow and contributing for distribution pattern As. High As aquifer sediments are composed of grey silty sands, whereas low As aquifer sediments contain white /brown sand and are reducing in nature with more sediment–water interaction. High Fe contents of the sediment are associated with high As in groundwater. Groundwater is predominantly reducing conditions at near-neutral pH with high HCO3- along with redox sensitive species and low concentration of SO42-, NO3-, DO. Another major challenge is As in food-chain. Bioaccumulation needs proper attention to regulate policy. Increased risk of As contamination is a challenging issue, risk has to be minimized. Aquifer mapping is necessary to delineate safe aquifer for drinking water supply, which will comply with the health-based guidelines for a long-term basis.

iii. Uranium rich groundwater in some parts of India: Geological context

Deepak Salim, Divecha Centre for Climate Change, IISc

Drinking of Uranium rich groundwater (water having Uranium more than 60ppb) and its extensive use in agriculture over long duration is considered health hazard. Many districts of Punjab, Haryana, Rajasthan, Gujarat, Andhra, Telangana and Karnataka and Tamil Nadu are reported to have high Uranium content going up to 350ppb. In the absence

of anthropogenic causes, geological environment assumes importance for such high abundance of Uranium in groundwater. It could be due to high Uranium content in Siwalik sediments in Punjab, Rajasthan and Gujarat; alkaline igneous rocks in Rajasthan; widespread uranium mineralization at shallow depths in Proterozoic sedimentary cover and basement granites in Andhra and Telangana; radioelement enriched K-rich late Archaean and Proterozoic granitoids in Karnataka and Tamil Nadu.

iv. Fluoride rich groundwater zones of Karnataka, India

Kavitha Devi Ramkumar, Divecha Centre for Climate Change, IISc

Parts of 20 districts among the 30 districts of Karnataka in southern India are at risk of being exposed to dental and/ or fluorosis because of high fluoride content in ground water. A holistic approach consisting of delineation of high fluoride ground water areas, their geological setting, petro-mineragraphic study of the aquifer rocks, geochemistry of the aquifers, water-rock interaction modelling, development of sustainable technologies, medical and nutritional intervention for reversing fluorosis, is required for solving the problem of fluorosis.

v. Drinking water quality and the CKDu occurrence in Wilgamuwa, Sri Lanka

Pasan Hewavitharana, Nephrology and Kidney Transplant Unit, Teaching Hospital, Kandy

CKDu has become a severe health issue in Sri Lanka. Although the exact causative factors are unknown, drinking Water is considered as one of the factors that contributes to CKDu. The main objective of this study was to systematically investigate the quality of the water consumed by CKDu patients in Wilgamuwa. The main objective of this study was to systematically investigate the quality of the water consumed by CKDu patients in Wilgamuwa, a recently identified CKDu hotspot in Uva Province. Information related to drinking water sources was collected through an interviewer administered questionnaire. Water samples were analysed according to standards methods. Majority of CKDu patients (84%) consumed moderate to hard water and the hardness values were above the threshold levels for human consumption according to WHO guidelines.

8. Groundwater Quality and Assessment I

Fig 33: Groundwater Quality and Assessment I session in progress.

i. Groundwater resources assessment in Jordan Mohammad Alhyari, Ministry of Water and Irrigation

A nation-wide survey was carried out to assess the current groundwater situation and to evaluate the changes that have occurred since the last groundwater assessment from 1995. Groundwater level contour maps and thematic maps were produced for the different aquifers at a national scale. The long-term groundwater monitoring data shows a continuous groundwater level decline in most of the aquifers by up to several meters a year in some areas. The present study covers the main aquifers and carries out a trend analysis over the last twenty years. The results show a dramatic groundwater situation, which is highly relevant for decision makers in the water sector. They provide a sound scientific base on which the political discussion on water reallocation or the exploitation of alternative, more expensive water sources can be build up.

ii. Fractal analysis of water quality time series data by Hurst Exponent and confirmation of its instability by estimating Largest Lyapunov Exponent Sangeeta Mishra, Thakur College of Engineering and Technology, Mumbai

Fractal dimension, D of WQD is

computed by Hurst exponent (H). Rescaled range analysis has been carried out to estimate the value of H and D. The Hurst exponent can classify a given time series in terms of whether it is a random, a persistent (long term memory) or an anti-persistent process (short term memory). Further, the presence of chaos in WQD (a dynamical system) is detected by evaluating LLEs. Concentrations of water (Bore well samples) quality indicators of various districts for Karnataka has been collected for the study. Concentrations of the indicators such as fluoride, nitrate, manganese, sulphate, total hardness, total dissolved solids, iron and pH are measured in the samples of water collected for a period ranging from 2010-2018. Bagalkot district of Karnataka state is selected as our domain of study. The Hurst exponent (H) of the mean concentration of all these water quality indicators during the period mentioned estimated as more than 0.5 but less than 1, which indicates that water samples of Bagalkot are of persistent in nature (long memory effects) and the trend at a particular point in time affects the remainder of the water quality time series. The estimated value of LLEs of the same data shows that there exists a chaos (instable) in the data.

iii. A multi-layered aquifers groundwater model for leakage assessment of arsenic contamination threat in a part of Ganga basin

Virendra Tiwari, CSIR - National Geophysical Research Institute

The study presents groundwater flow model of a multi-layered aquifer system from a part of middle Ganga River Basin, Patna, Bihar, simulated for understanding the hydrodynamics under steady and transient conditions for assessment of groundwater leakages by assigning input and output stresses now and on the projected ones. Model utilizes 3D aquifer geometries from geophysical observations and aquifer properties from in-situ measurements. The results revealed that the groundwater dynamics between two aquifers with increasing pumping from AQ-II is leading to rapid depletion of piezometric head and possible mixing of arsenic contaminated water to the deeper aquifer from the shallow aquifer. This reversal in the inter-aquifer leakage has been simulated in both regional and microscales, and the areas vulnerable to the leakage reversal have been indicated. The results provide safe pumping rates at a micro-scale for the farmers and sites for the decision-makers to provide alternate supply of water.

iv. Assessment of water quality at fluoride affected village Dikharomukh of Hojai District of Assam

Dharani Saikia, INREM Foundation

Dikharomukh village, an identified fluoride endemic area is located at Hojai district of middle Assam. Government of Assam has taken an initiative of fluoride free Pipe Water Supply Scheme (PWSS) in the year of 2013 to mitigate the problem, but still cases of fluorosis occurred frequently. There are three types of drinking water sources like ring well, hand tube well and a PWSS. The

main objectives of the study were to identify the existing gaps of present water sources and to find out an easy, low cost, acceptable and sustainable solution. Through PRA methodology and various tests conducted it may be concluded that ring well is the best source of water for domestic uses.

v. A covalently integrated electro-adsorbent ion exchange resin for efficient capacitive deionization (CDI)

Md Islam, Indian Institute of Technology, Madras

The present invention describes the preparation of an efficient electrode for CDI via in-situ polymerization with styrene monomer onto rGO to create a single molecular construct for electro-adsorption and selective ion permeation. This electrode was used in desalination process for the removal of different ions (viz. cations of different charge including Fe3+, Mg2+and Na+ and anions of different charge including Cl-,NO3-, F-, SO42- In this work, an integrated electro adsorbent-ion exchange resin using graphemic materials is synthesized. The material was hiving high surface area, electrical conductivity, porosity and high specific capacitance and was found to be a perfect candidate for CDI electrodes. The material was used as an active CDI electrodes and experiments were performed for removal of different ions (having different charge and valency) from water. It was observed that the adsorption capacity of the composite are 3-4 times higher than normal graphemic materials/other carbon materials and have excellent cyclic capability.

vi. Machine learning approach to compute water quality index with uncertainty

Debabrata Datta, Bhabha Atomic Research Centre

Decision maker's usual objective is to reduce to zero the gap between the simulated and the observed system behaviour, but this goal is generally impossible owing to the unavoidable uncertainties inherent in any modelling procedure. Uncertainty analysis in water quality (WQ) modelling can provide information on the goodness of WQ status and enables to pin down the hotspots. The paper presents the Bayesian earning scheme for computing water quality index by fixing the appropriate prior probability distribution of measured concentration data of water quality indicators. Water quality data by this method can be converted into a structure data which can be used to draw the decision trees so that multilevel decisions can be taken to develop further an epidemiological model. Health risk assessment is recommended via an epidemiological model provided the given data represents the drinking pathway of exposure.

9. Leaving No One Behind: Digital Water, Big Data, Technology and Water Security

i. Smart water solutions: A risk communication tool for sustainable water future in West Bengal, India

Bhaswati Ray, Sivanath Sastri College, University of Calcutta

The world is facing global water crisis with the capacity of the hydrological cycle outstripped by increased demand, pollution of water resources and poor water management. The United Nations World Water Development Report 2017 warns that, by 2030, only 60 percent of the world's water demand will be met by existing water resources. Water scarcity is likely to be severed by climatic stress, rising demand and pollution. The rural population in West Bengal, India are affected by diminishing water reserves and exposure to contaminants like arsenic, salinity and fluoride in the groundwater system with severe health impacts. A web-based interface would help in information sharing amongst all stakeholders and co-designing smart water solutions.

ii. Understanding decadal LULC patterns in Cauvery river basin using Google Earth Engine

Ganesh, ATREE, Bangalore

Landuse/landcover change is a major issue faced in peninsular India which includes Cauvery river basin in southern part of Karnataka and northern part of Tamil Nadu states in India. This study accounts for the change in major land use classes along Cauvery basin for the year 1991, 2001, 2011 and 2016. The Landsat imagery dataset from USGS has been classified using Google Earth Engine. The major focus of study is on agricultural classes, which were derived seasonally. This study was conducted to analyse decadal change in Cauvery river basin. Use of seasonal variation of satellite imagery composites helped in detecting agriculture land use with more accuracy.

iii. Developing regional water security indicators to support sustainable water futures

Sophie Sheriff, University of Dundee

Across river basins, patterns of water availability may vary considerably. However, achieving water security must consider many other aspects including water access, local- and basin-scale management, quality and the extent and magnitude of water-related hazards. Prioritising areas to target basin management strategies also requires an appropriate evidence-base, which requires understanding and representation of the variability of water security over space. The aim of this study was to develop a regional water-security assessment methodology. Aligned to the abovementioned challenges, the

objectives were to, i) consider multiple water use sectors and, ii) integrate additional water security measures with water availability, iii) support uptake of results for decision-makers.

iv. Linkages in water quality variation and hazards among artisanal aquaculture along the Indian coast

Rosewine Roy, Presidency University

The paper focuses on interlinkages between water quality variation - Hazards-Economic Risk in aquaculture along with southern coast of India. The Aquaculture production is traditional in nature and dependency on natural resources are very high. The Hazards such as mortality, diseases and retarded growth posed by water quality changes could lead to economic risk for aquaculture farmers. The analysis shows with water quality changes there is variation in hazards, however, resource management practices of the community could manage the hazards through various collective action measures.

Fig 34: Leaving No One Behind: Digital Water, Big Data, Technology and Water Security session in progress.

10. Water Assessment in River Basins: Perspectives

i. Assessing hydrological scenarios through basin futures

Kangkanika Neog, Council on Energy, Environment and Water, New Delhi

Water Resource Planning and Management encompasses activities like planning, developing, and managing the quantity and quality of water resources among all water users. However, with the increasing understanding of limitations on water supply and growing demand, several reformulation of water resource planning methods globally. Our research takes a step-back from the traditional method of water resources planning and delves into these new paradigms. The study recommends inclusion of water conflict vulnerability assessment and stakeholder engagement over and above the traditional linear water resource planning as it exists now.

ii. Imputation of missing rainfall data by artificial neural network with different activation functions for Dabhoi

Sanskriti Mujumdar, The Maharaja Sayajirao University of Baroda

Climate change studies involve long term analysis of precipitation data, comparison of observed data to that available using GCMs / RCMs where inconsistency or missing values can give misleading results. Imputation of missing values in observed data is essential requirement for researchers before they move on to compare it with downscaled values of climatic models where ANN can be used effectively. Inconsistency or missing rainfall data can give misleading results. This research focuses on imputation of missing daily rainfall data by following climate pattern using observed data of stations before and after missing data period along with use of observed data of nearest rain gauges stations. The concept is applied for rainfall data for three stations of Dabhoi taluka of Vadodara district of Gujarat.

iii. Dam break modeling using HEC-GeoRAS and HEC- RAS : A case study on Aji-1 Dam, Gujarat

Apurba Nath, NIT Silchar

Flood forecasting is a process where we can estimate and predict the magnitude and timing of flood by using earlier flood records of that zone. India has witness of some of most dangerous catastrophic flood due to several reasons such as structural failure, maintenance error, earthquake failure etc. Dam break failure is one of the key factors of flash flood. It is essential to make an Emergency Action Plan (EPA) in advance to take some preventive measure before dam failure. The primary purpose of the study is to determine the risk zone as well as inundation depth and inundation extent, if dam break occur considering various scenarios. The model also gives

information about magnitude and time of flood related knowledge.

iv. Effect of community buy-in and availability of funds on the long-term legacy of sanitation projects

M. Nazli Koseoglu, The James Hutton Institute

Over recent decades significant amounts of resource and effort has been directed to WASH projects to address the challenges of insufficient safe water supplies and poor sanitation. However, despite these benevolent investments, when planned without the inclusion of socioeconomic factors, sanitation infrastructure gradually become dysfunctional, either abandoned or used for purposes different from the initial objective of sanitation. Life cycle costing (LCC) methodology enables an estimation of the scale of the full economic burden of maintaining and operating the sanitation infrastructure on communities. This study addresses the major gap in LLC applications to sanitation projects by analysing different scenarios of community buy-in and funding availability.

v. Socio-hydrology model of inter-basin water transfers with stakeholder elicitation

Sai Veena Sunkara, Indian Institute of Technology, Bombay

Inter-Basin Water Transfers (IBWTs) are a common approach for managing water scarcity that seeks to take advantage of the regional differences in the variability of water resources. We develop a socio-hydrological model for an IBWT scheme in southern India named Inchampalli-Nagarjuna Sagar link for transferring water from Godavari river basin to Krishna river basin. A socio-hydrological model that accounts for bi-directional feedbacks and improves predictability is developed for interbasin water transfer system. The model shows the importance of feedback between the donor and recipient basins for water transfers.

vi. Insights from studying patterns of co-evolution of agriculture-water at watershed scale in Cauvery Basin

Neha Khandekar, ATREE, Bangalore

India is a rapidly evolving economy with several sectors heavily relying on water for day to day operations, with rising demands from various sectors and stakeholders including the environment. To apportion water fairly and sustainably within river basins, a reasonable estimate of water availability is sought. Water availability projections in a typical hydrology model are carried out over a period of time using hydro-meteorological input parameters and refining the model for given context. Within the growing uncertainties globally and human–water systems become highly inter- connected, this study takes a step forward in the need to extend the science of socio-hydrology to develop understanding of evolutionary patterns within a basin complicated with inter-connected human-water system as Cauvery; to be able to form humans as endogenous part of the modelled system for studying it in its entirety.

11. Water and Climate Change Assessment I

Fig 35: Water and Climate Change Assessment I session in progress.

i. Hydrological controls of methane emissions in contrasting inland water bodies

Carole Helfter, Centre for Ecology and Hydrology

We studied methane emissions from two contrasting inland water bodies (River Thames, London, UK and Okavango Delta, Botswana) using eddy covariance and flux footprint analysis. Continuous, spatially integrated monitoring at fine temporal timescale is inherent to this technique and this allowed for the investigation of diurnal and seasonal flux dynamics. We established unequivocal correlations between the natural hydrological cycles and methane emission patterns at the two sites. Using state-of-the-art methodology, we demonstrate that natural hydrological cycles are the dominant controls of methane emissions in two very different aquatic systems. These cycles being inescapable, we suggest that careful water quality management is essential to minimise the future aquatic global warming potential in a changing climate.

ii. Probabilistic assessment of agricultural economic impacts of regulatory drought management

Ian Holman, Cranfield University

Drought frequency and intensity are expected to increase in many regions and water shortages could become more extreme, even in humid temperate climates. This presentation describes a novel approach for the probabilistic risk assessment of current and potential

future economic losses in irrigated agriculture arising from the interaction of climate change and regulatory drought management restrictions, with an application to England and Wales. The study suggests that collaborative approaches between environmental regulators, agriculture and other water users is needed to balance the multiple competing demands for water (including the environment) within a changing climate, whilst supporting food security, resilience and rural livelihoods.

iii. Impact of climate change on water resources of the Rushikulya basin Damodar Panda, Utkal University

The main aspect of the paper is the rainfall and runoff are closely associated. The evapotranspiration and the temperature trends are showing declining trend. The ground water potential is very high due to the porosity of the basin. The need of the hour is the storage of more rainwater during surplus time. The basin trend is opposite to the trend prevailing in the globe.

iv. Climate change impact and uncertainty analysis of IDF curves in the Bhubaneswar city, Odisha Meenu Ramadas, Indian Institute of Technology, Bhubaneshwar

Rainfall intensity-duration-frequency (IDF) analysis is an important concept in hydrologic design. In recent times, urban flooding and urban drainage problems had affected several major cities of India and other countries resulting in loss of life and economic damage. Several of these events were attributed to changing climate patterns and rainfall characteristics under urbanization and potential climate change. The present study investigates the changing characteristics of IDF curves of urban Bhubaneswar due to potential climate change.

v. Adaptive EEMD-ANN hybrid model for forecasting south west monsoon of Kerala Kavya Johny, Amrita School of Arts and Sciences, Kochi

Forecasting Summer Monsoon Rainfall of India is a complex problem for the hydrologists and meteorologists. The use of hybrid decomposition-data driven models are the recent improvements, but these approaches differ significantly in the framework adopted. This study presents an adaptive hybrid modelling framework so called Adaptive Ensemble Empirical Mode Decomposition-Artificial Neural Network (AEEMD-ANN) model for forecasting South West Monsoon Rainfall of Kerala. The diverse statistical measures show the improved performance of AEEMD-ANN over EEMD-ANN hindcast and forecast strategies. Along with the mean predictions, the model could capture the critical dry and wet year rainfalls of the State reasonably well.

vi. Investigation of extreme precipitation event over Kerala from the perspective of climate change and

cloud microphysics parameterization
Leena Khadke, Indian Institute of Technology, Bhubaneswar

The research effort is trying to highlight the contribution of climate change for the occurrence of extreme events and to quantify the high-resolution numerical model's ability to accurately predict these events with adequate lead time. The initial results are reflecting that the microphysics scheme has a great impact on forecast skill. Also, model under-estimated the precipitation over the ocean and overestimated over land possibly due to orographic convection. This study not only aims to identify the role of climate change through long term past data analysis but also efforts are made to understand the performance of the high-resolution model in replicating these events.

12. Water and Climate Change Assessment II

i. The impact of climate change and climate variability on the hydroclimatology of a major river basin of India before and after 1980
Sonali Pattanayak, Divecha Centre for Climate Change, IISc

The most striking feature of this study is the shifting of observed signals before and after 1980 over Mahanadi river basin. This analysis has provided convincing evidence that one of the India's major river basins Mahanadi has experienced an altered hydroclimatic condition after 1980. It can be concluded that Mahanadi river basin is sensitive to both climate change and variability and it has altered with respect to considered time periods and seasons. The study suggests that both climate change and variability are likely to impact the overall hydroclimatological changes in future. The mapping of the observed temperature and precipitation changes and their correspondence to the large-scale circulations and climate change impacts could have important implications for water resources management. This mapping will be useful for the policy makers in developing appropriate management strategies.

ii. Increasing drought severities due to changing cropping patterns in Marathwada
Sneha Kulkarni, Indian Institute of Technology, Bombay

This study deals with the drought severities with respect to the trends in summer monsoon rainfall, groundwater fluctuations, soil moisture variability and changing crop types over the Marathwada region, Maharashtra, India. This analysis has been carried out for the period 1996 to 2016. Over this region increasing water

scarcity and depleting groundwater level have accentuated the agrarian crisis and farmers distress from the last few decades. The present study is based on both the climatic and anthropogenic roots of enhancing the drought severities. This study tries to investigate the interlinked relationship between rainfall vagaries, soil moisture fluctuations, changing cropping patterns and droughts.

iii. Detection of acceleration in hydrological cycle: evidences from the river basins draining Southern Western Ghats, India

Merin Mathew, National Centre for Earth Science Studies

The acceleration of global hydrological cycle is likely to be due to climate change leading to increase in number of extreme rainfall events and increased rate of evaporation. Potential consequences of anthropogenic climate change in water resources have been widely investigated and numerous studies suggest that climate warming is likely leading to alteration and intensification of hydrologic cycle. The Trends in hydro-meteorological variables has been examined using Mann-Kendall, Sen's Slope Estimator and sequential Mann-Kendall tests to determine the change point in hydrological regime. A decreasing trend in rainfall and streamflow was observed during the months of June and July; and a comparatively increasing trend in the months of August and September.

iv. Can a calibration-free dynamic rainfall? Runoff model predict FDCs in data-scarce situations

Basudev Biswal, Department of Civil Engineering, IIT Bombay

Regionalization methods are commonly followed to solve the problem of discharge data scarcity by transforming hydrological information from gauged basins to ungauged basins. As a consequence, regionalization based FDC predictions are not very reliable where discharge data are scarce quantitatively and/or qualitatively. In such a scenario, it is perhaps more meaningful to use a calibration-free rainfall runoff model that can exploit easily available meteorological information to predict FDCs. The objective of this study is to test the hypothesis that a calibration-free dynamic rainfall runoff model can be used to predict FDCs in data-scarce regions.

v. Copula-based bias correction scheme for zero-inflated RCM precipitation fields

Rajib Maity, Indian Institute of Technology, Kharagpur

Bias correction of RCM output is required before being used in hydrological modelling. The propose methodology aims to overcome either of two shortcomings of the existing methodologies: i) focus on the bias in either mean or extreme not all the quantile, and ii) exclude zero values from the analysis. A mixed joint distribution between observed and RCM precipitation is formulated using copula with proper consideration to zero values.

13. Data Issues and Needs Related to Monitoring Sustainability in Water Space

i. Improving the spatio-temporal representation of precipitation in data-scarce regions

Oscar Baez Villanueva, TH Köln

An accurate representation of the spatio-temporal variability of precipitation is crucial for a wide range of hydrological applications. In many developing countries, the network of rain gauge stations is sparsely distributed, therefore the use of only ground-based measurements to represent the spatial variability of precipitation is subject to large uncertainties. There are several reanalysis- and satellite-based precipitation products, however, studies have shown that they still present multiple sources of errors. Therefore, this study presents a novel methodology capable to improve the spatio-temporal representation of precipitation by merging different precipitation products and ground-based measurements.

ii. Spatial downscaling of satellite remotely sensed soil moisture and rainfall over Karnataka

Subash Yeggina, Indian Institute of Science

Accurate precipitation and soil moisture data with high spatial resolution are crucial for many applications such as irrigation management, groundwater modelling and water budgeting. Further accurate, high spatial resolution are crucial to improve the understanding of temporal and spatial variations. In this study, we presented a simple regression model and compared with random forest-based approach for spatial downscaling annual TRMM 3B43 rainfall from spatial resolution of 25 km to 1 km for Karnataka. The following objectives are laid in the present study. To downscale the soil moisture and rainfall from coarse to fine scale. To assess the optimum scale of the downscaling for each variable.

iii. Calculating satellite derived bathymetry (SDB) of Mettur reservoir over time to show the decrease in the capacity of the river due to accumulated sediments

Choppakatla Lakshmi Pranuti, ATREE, Bangalore

Estimating the storage capacity of reservoirs is a major problem in India especially when there is continuous sediment deposition. Field-based techniques using DGPS and echo sounder are the most widely used for volume estimation but are expensive. Given the time and the number of reservoirs it is difficult to carry out these estimations using the field-based techniques at regular intervals. Satellite derived bathymetry is a better option. The study used the Stumpf model. The study utilizes Blue and Green Bands in Google Earth Engine to calculate the Satellite-Derived

Fig 36: Data Issues and Needs Related to Monitoring Sustainability in Water Space I session in progress.

Bathymetry. The model uses difference in absorption of each band and the ratio of these to know the corresponding water depth. The objective is to provide evidence of siltation and calculate volume estimation of the reservoir using satellite derived bathymetry at regular intervals for particular tunable constants.

iv. Morphometric analysis of river Sabarmati basin, Udaipur, Rajasthan India, using remote sensing and GIS techniques
Pooja Kumari, Central University of Gujarat

In developing countries like India, natural resources like land, water and soil are normally depleting day by day, due to their wide utilization with increasing urbanization, industrialization and population. Therefore, planning and management of these resources is required for sustainable development. Watershed prioritization based on morphometric analysis has gained importance in soil and water conservation and management. Remote sensing and GIS techniques for drainage analysis are very valuable and time saving. The morphometric analysis of a watershed provides information regarding the watershed characteristics, drainage pattern, basin geometry, regional topography, nature of bedrock and groundwater potential zones etc. It is also found to be of immense utility in watershed prioritization and conservation of natural resources at watershed level. These results may be used in basin management development and hydrological studies. This would enable water to be made available in nearby water scarce area as well as to increase possibilities of efficient utilization. This would also help to prevent soil erosion and to mitigate the hazards by improving soil conservation.

14. Freshwater Conservation and Development Planning: Novel Integrative Approaches and Big Data

i. Global Dam Watch: curated global dam data for all

Penny Beames, McGill University

Global Dam Watch is an initiative by leading academic institutions and NGOs to curate and share high quality, freely available global dam data. This effort builds on work done by the Global Water System Project to create the Global Reservoir and Dam Database, which was published in 2011. GRanD was developed by more than 15 researchers and institutions (Lehner et al. 2011). The initiative aims to maintain the world's most comprehensive, freely available global dam data by curating information on the location and characteristics of dam, reservoir, and river barrier datasets at global and regional scales.

ii. Freshwater biodiversity research from local to global scales

Sonja Jähnig, Conservation International

Over a decade ago it was stated that the protection of freshwater biodiversity is "the ultimate conservation challenge" and "immediate action is needed." However, conservation is still failing freshwater biodiversity. The 2018 Living Planet Report shows an 83% decline in monitored species in freshwaters. Solutions urgently need to be found. Landscape managers need better guidance on how to integrate conservation management of inland waters into their decision-making. Policy makers need clearly defined targets and practical indicators for assessing progress towards the conservation and sustainable management of inland waters and their species. The conservation community has an essential job to play in providing the necessary guidance to land and water managers and policymakers on how to integrate conservation management of inland waters into landscape decision-making.

iii. Conservation planning in human dominated riverscapes: case study of Ganga

Michelle Irengbam, Wildlife Institute of India

Wetlands of the Indo-Gangetic plains support major human settlements but are undergoing severe declines. The study aimed to assess drivers of degradation of two seasonally flooded wetlands in Bihar and propose sustainable management options. Major drivers included overexploitation, pollution, encroachment and conflicting management regimes. The local communities persisted on a water economy, while the rest of the local economy was supported by agriculture. The study assessed drivers of wetland loss and proposed sustainable management solutions for these wetlands with management implications for other wetlands in the region.

15. Groundwater and Climate Change Adaptation

i. Holistic groundwater and surface water management for sustaining water resources in rapidly urbanizing cities: A case study in Madurai, India
Aman Srivastava, Indian Institute of Technology, Bombay

Historically, the Vandiyur Tank Cascade Systems (VTCS) have been a primary water source for the people of Madurai, a South Indian district in Tamil Nadu. In recent years, the VTCS water levels and groundwater levels in the region have sharply declined due to unsustainable groundwater extraction rates. Due to limited holistic hydrological understanding of the region, groundwater is still depleted, while conservation efforts at VTCS have limited efficiency. The current study showcases the importance of holistically managing groundwater and surface water resources for the betterment of the society.

ii. Feasibility of water storage in saline aquifers for drought resilience
Andrew McKenzie, British Geological Survey

The Sundarbans area of West Bengal is an example of a deltaic system with islands where the population rely on groundwater for public supply and irrigation. Groundwater resources are supplemented by farm ponds, but the low relief means that reservoirs can't be constructed without excessive sacrifice of productive agricultural land. The study explores the feasibility of using relatively small-scale ASR systems on deltaic islands to provide resilience against drought and the periodic loss of surface water storage from cyclone driven flooding through aquifer characterization and simulation.

iii. Groundwater sustainability in the face of climate change in India
Ratan Jain, Central Ground Water Board

Adaptation strategies proposed for mitigating the increasing stress on ground water resources due to climate change for enhancing recharge of groundwater aquifers, mandating water harvesting and artificial recharge in urban areas, ground water governance, incentivising to promote recharging of ground water, intelligent power rationing for irrigation ,optimizing water use efficiency, conjunctive management etc. have been examined at great length in terms of the technical feasibility as well as social relevance of implementation in the light of extensive experience gained in the country.

iv. Bhadar catchment: response of groundwater storage and river flow to anthropogenic and climate

drivers

Mohammad Faiz, International Water Management Institute (IWMI), India

Saurashtra region in state of Gujarat, located in western-most part relying heavily on groundwater for irrigation has witnessed widespread groundwater depletion. However, in recent years, there has been signs of improvement with number of the studies corroborating the increase in groundwater storage or reversal from earlier declining trends. However, the verdict on primary cause for the change remains divided between anthropogenic and climatic factors. More than 50,000 decentralized RWH structure built has received fair of attention and is stated to be the primary reason behind the improvement, however a closer inspection reveals that evidence supporting is either local, or anecdotal lacking scientific rigor. Here, we fill this gap by looking at relative contribution of anthropogenic and climatic drivers in the observed improvement in groundwater storage.

16. Resilience in Urban Water Systems: Methods

i. Understanding the effect of urbanization on water resources in Cauvery basin

Rashmi Kulranjan, ATREE, Bangalore

As urbanisation continues to grow rapidly the consumption of resources gets higher. Resources being scarce, there is a need to account for the demand for water from cities. In this study, abstracted water quantity and population density in towns were assessed through the analysis of time series dataset (1991-2011). An attempt has been made to find a relationship between the extent of urban area as detected from remote sensing data, population distribution and the level of abstraction of water. A river basin approach is chosen as all hydrological process within the basin are interconnected and interdependent.

ii. Demystifying household water scarcity in Coimbatore using continuous sensor data

Apoorva R, ATREE, Bangalore

In India and similar countries with intermittent public water supply and multiple source dependence, this study aims to understand the nature of constraints faced by households in accessing adequate water. When constrained by inadequate water supply or storage capacity, public water supply systems need to be adapted to address them. In contexts where water pricing is often considered as an important lever for controlling urban water demand, this study helps unpack the nature of urban water scarcity.

iii. Applied mineralogy for sustainable water future

Gopalakrishna Parthasarthy,

National Institute of Advanced Studies

In this talk the importance of applied mineralogy in water treatment studies are discussed, with significant interdisciplinary approach. Applied Mineral Chemistry, a growing transdisciplinary research field that, encompasses such diverse disciplines as the prospection, extraction and refinery of ores, the manufacturing of materials, and the impact of minerals on the environment and on human health. In this paper the following aspects are discussed: (i) mineral chemistry of high pressure clay minerals and their application in salinity-related problems, (2) Mineral Chemistry of trioctahedral phyllosilicates and their application in environmental chromium related water problems and (3) Role of hydrous sulphates in arsenic related water science, with a focus on sustainable development.

iv. Understanding water flows : Bhubaneshwar and Dehradun

Aishwarya Varadharajan, Medha, Development Alternatives

Raw water, potable water and wastewater in urban environments are often viewed in isolation rather than in coherence in Indian cities. To enable a systemic understanding of the entire value chain of water across a city, a study has been carried out in four Indian cities, assessed to be among the most vulnerable. The paper describes the urban water system of 4 Indian cities by assessing vulnerability, sustainability performance and the findings in relation to SDG6. It includes a quantitative analysis of the water available across all stages of the value chain through developing volumetric flow diagrams and a framework for evaluating each city's water network through four lenses of sustainability.

v. Feasibility study of a new approach in modeling municipal residential water consumption estimation using climate variables

Surendra J, Atria IT, Bengaluru

A major concern for several researchers experienced in any estimation technique is the lack of quality and quantity of the data. The effect of combined and individual parameter analysis for modeling water consumption has not been studied so far in a comprehensive manner. Proper methodology to improve the accuracy of the fuzzy technique, when the data are nonlinear and non-stationary is very few. So, there is a wide scope to improve the accuracy of the fuzzy technique. Development of Fuzzy-wavelet hybrid models for various input scenarios based on climatic variables. Performance Evaluation of developed hybrid model with other model like ANFIS and selection of best model. In this research work, Discrete Wavelet transform is coupled with fuzzy logic method to improve the accuracy of the estimation. The proposed study involves the development of Wavelet-Fuzzy technique for modeling the urban water consumption estimation.

17. Urban Flood Risk and Adaptation

Fig 37: Urban Flood Risk and Adaptation session in progress.

i. Flood risk awareness and communication Hrushikesh Sandhe, Walter P Moore

The objective of the presentation is to share basic data needs for urban flood risk awareness and communicating with stakeholders. The flood and floodplain basic information should be shared and educated with local community. This information can be shared using an internet-based interface. This will help reduce damages and loss of life during severe events.

ii. Assessing the effect of model structure uncertainty on the simulation of urban floods

Claris Thomas, Indian Institute of Science

Urban flooding is the major problem faced by most of the cities in India due to inadequate capacity and encroachment of drains and water bodies, poor maintenance of storm water drains, improper planning, and climate change. The drainage system in Bengaluru is currently insufficient to cope with the increased volume of water generated from high-intensity rainfall and as a result, the runoff inundates the urban settlements in low lying areas and submerges the roads. So, the study aims at assessing the effect of model structure uncertainty on the simulation of urban floods and also to identify the sensitive flood prone over the study area.

iii. Legislative framework for urban flooding and water conservation for Bangalore

Reshmi Manikoth Kollarath, BMS College of Architecture

Cities globally have been facing problems related to water management leading to water shortage during the dry periods and cases of urban flooding during rainy seasons. This is true in the case of many Indian cities and especially in the Bengaluru Metropolitan region. This uncontrolled growth has led to the encroachment of natural catchment areas and increased the impervious areas in the city. This paper explores the conservation of excess water during the monsoon season which causes urban flooding for reuse during periods of scarcity. The objectives of the study include identification of areas in the Bangalore Metropolitan Area which are prone to urban flooding, redeveloping the drainage pattern for more efficient disposal of excess storm water into collection ponds traditionally called Kere and integrating water conservation and development plan with its system of Raja Kaluve and Kere into the city development plan.

iv. Design of road crossing for prevention of floods

Gowri Shankar, Department of Chemical Engineering, Ramaiah Institute of Technology, Bangalore

This paper presents an approach to estimate reliability of a SWD network (system) in fuzzy framework. The approach includes: (i) estimation of reliability of conduits in SWD network in fuzzy framework, (ii) construction of a reliability block diagram (RBD) for the network, and (iii) use of the RBD and conduit reliability estimates to compute reliability of SWD network using Fuzzy Monte Carlo simulation-based procedure.

18. Water and Climate Change Assessment: Himalayas

i. Hydro-meteorological drought and wet patterns under changing climate in Uttarakhand hills

Anil Kumar, G.B. Pant University of Agriculture & Technology

This study was conducted to assess meteorological and hydrological drought and wet patterns at two stations, Naula and Kedar, located in the Ramganga River catchment in Uttarakhand State of India. Rainfall and streamflow data time series were used to analyse meteorological and hydrological drought and wet patterns using Standardized Precipitation Index (SPI) and Standardized Discharge Index (SDI) at multiple time scales of 1-, 3-, 6-, 9-, 12- and 24-months. The primary objective of this study is to assess the hydro-meteorological drought and wet conditions at two stations, Naula and Kedar, located in the upper Ramganga River catchment in Uttarakhand, India.

ii. Variability in snow cover area (SCA) in relation with meteorological parameters of Dokriani Glacier catchment, Central Himalaya

Jairam Yadav, Kurukshetra University

Snow cover plays an important role in mountain hydrology, availability of water in the river system and avalanche events. Our effort to integrate remote sensing (Landsat 5 TM, 8 OLI and Sentinel MSI) with meteorological data set (Temperature, RH and solar radiation) were pointed out interesting results. Obtained isotherms (~ 0, 1, and 2°C) were analyzed by an extrapolation method using near-surface temperature lapse rate (NSTLR). The present study aims to: (1) evaluate spatio-temporal variability of snow cover; (2) assess possible relationship between snow cover extent and meteorological attributes; (3) reconstruct snow cover extent using concept of isotherms. This study is more significant for demonstrating the future scenarios of glacier recession.

iii. Estimation of recent snow series over Mount Lebanon from gap filled MODIS snow cover products assimilated in an ensemble of dynamically downscaled ERA5 reanalyses

Esteban Alonso-Gonzalez, Pyrenean Institute of Ecology, Spanish Research Council

Seasonal snowpack exerts a key role in many hydrological and ecological processes over the world. Thus, it is mandatory to obtain reliable multiyear snowpack data for several scientific and operational applications. At most of the mountainous regions of the world observational data of snowpack does not exist, or the series are too sparse, small or incomplete. New high-resolution snowpack dataset for Lebanon was developed. We have used the state-of-the-art reanalysis, mesoscale models, gap filling remote sensing algorithms and data assimilation routines to generate the snow series. The current approach investigates the possibilities of developing high resolution snow datasets over regions with no observational data with relatively low computational expenses.

iv. Community-based fluorosis mitigation in Dhar district, Madhya Pradesh

Debashish Sen, Peoples Science Institute

Fluorosis is a disease caused by high concentration of fluoride in drinking water drawn from the ground through sources like handpumps and tube wells. It results in physical deformities which affects socio-economic conditions of the people. The case study presented here is of Dhar district in Madhya Pradesh where this crippling disease is affecting vulnerable population groups and children. The major cause is dependence of people on groundwater which has high fluoride levels. There is an urgent need to promote safe sources of drinking water based on hydrogeological studies and participatory approach. This kind of participatory and scientific approach is safe, sustainable

and less expensive than the installation of defluoridation units attached to hand pumps which become dysfunctional after some time. Awareness and community-led actions are essential for the success of such programs. This in turn requires informing policy makers and civil society organizations about fluorosis mitigation through participatory approach. The objective of the work was to provide access to naturally occurring fluoride safe drinking water to those most in need through community involvement.

v. Role of snow/glacier melt runoff in Pindar River, Central Himalaya

Ningombam Prikash Meetei, Wadia Institute of Himalayan Geology

Snow/glacier melt is a vital component of the river flow for the Himalayan river. The sources of the Himalayan rivers are snow/glacier melt runoff, rainfall runoff and baseflow. In the present study, hydrological modelling has been applied to assess the contribution of snow and glacier melt runoff in Pindar river. By using SNOWMOD , the snow/glacier melt runoff contribution is estimated to be ~33 %, while rainfall runoff and baseflow contribution is to be estimated ~24 % and ~43 % respectively.

19. Governance: Knowledge Management and Innovation

Fig 38: Governance: Knowledge Management and Innovation session in progress.

i. Water security and integrates urban water management

Peter Scales, The University of Melbourne

True urban water security involves a range of outcomes including resilience of supply, guaranteed high quality potable water, the ability to use a wide range of water sources and outputs to the environment that are pollution free or guaranteed to do no harm. An integrated treatment process able to take in water from a range of water sources has been developed and validated, inclusive of guarantees of performance for both pathogens and chemicals.

ii. Circular economy of wastewater in Delhi

Ishita Jalan, Council on Energy, Environment and Water

The research study is focused on highlighting the challenges and opportunities that exist for the stakeholders to develop circular economy solutions for municipal wastewater. The study provides a framework for the urban local bodies and businesses to identify the potential value in creating an intervention of circular economy in their water systems. The framework was developed through an interview with fourteen experts in wastewater along with a literature review of seventeen international cases on circular economy of wastewater. The framework that was developed incorporated institutional and regulatory contexts, business cases, scale, participatory approach, finance and technologies.

iii. CityRehydrate : comprehensive toolkit for sustainable city water projects

Aishani Goswami, TERI School Of Advanced Studies

Increasing awareness of climate change and water scarcity among citizens and organizations leaves them concerned and often in a state of helplessness as to how they could help. This state often arises from not having enough knowledge in the water related subjects or not knowing whom to approach and how to go about. The intention of this study is to develop CityRehydrate, a toolkit as a guide to help these interested people to take action, according to their intended objective for their project.

iv. Effect of STEM education and subjects like local issues and its solutions

Padaraj Umakanta Nayak, Government High School, Alpingal, Jagatsinghpur, Odisha

Function of students plays a vital role for the development of a country. Scope for them from elementary stage to recognize, finding the cause, making plans & make some scientific hands on models to solve local water problems can lead to a better water future. Introducing a practical based subject “Local issues & its solution” & integration of STEM education in school curricula can be considered to provide such scopes for

developing interest & process skill of the students.

v. Integrated urban water management scenario modeling for sustainable water governance Chitresh Saraswat, Australian National University

The goal of ensuring water availability and sustainable management of water for all by 2030 is one of the top priorities of the UN-SDGs. The fragile institutional capabilities induce the transitioning towards the sustainable urban water paradigm to accommodate the uncertainties. This research draws sustainable water management strategies to achieve water security after a literature review, policy analysis, and scenario modeling. First, research illustrated the analysis of unmet water demand and total demand coverage using WEAP model to understand the impact of external factors (population growth, living standard, and climate change) on the current water supply system. system. At the later stage, the study designed the management strategies to evaluate the effective strategies using scenario modeling. Various management strategies were based on four different future scenarios (optimistic, moderate I and II and business as usual) to compare unmet water demands by the year 2030.

vi. Water management and Sustainable Development 2030 Agenda - Global governance and local action Nidhi Nagabhatia, United Nations University- Institute for Water, Environment and Health

Effective water governance interventions require appropriate and effective water security policies, a thorough understanding of the interconnected socio-economic, socio-cultural and socio-political interlinkages. And, solutions to address water accessibility, availability, and quality-related challenge, requires balancing science, technology, and financial commitments moving towards a development goals/targets-oriented pathways. To advance and enhance engagement, equity and inclusivity challenges in the water sector it remains pertinent that diverse stakeholders' needs integrate into governance agenda and action planning. The plans and activities based on critical ideas, policies, and practices that can effectively steer and shape a sustainable water future.

vii. Can resource efficient technologies resolve India groundwater crisis? Reflections from Gujarat Chandra Bahinipati, Indian Institute of Technology, Tirupati

Adoption of resource efficient technologies alone can't solve India's groundwater crisis. however, it should be noted that we, based on the finding, do not categorically deny the possibility of declining groundwater use due to large-scale adoption of such technologies since negative coefficient values are found. From a policy angle, the study suggests

that the promotion of these technologies may not lead to sustainable groundwater conservation outcomes unless the farmers are made to behave responsibly especially under extreme water scarcity conditions. It is also important that while supporting for the adoption of these innovations, the state also should effectively regulate the pilferages in farm power use by expediting the process of metering of unmetered connections, to achieve the desired goals of sustainable management of groundwater.

20. Water-Energy-Food Nexus Governance

i. A case for sustainable integrated water resources management using system thinking approach

Sridharan Ashwin Ram, Madras School of Economics

Models are very important tool for decision making and it has become very prominent and an integral part of studying Complex Dynamic Systems (CDS) across various disciplines. There are several modeling techniques emerging and being used across various fields as an aid to effective policymaking. A growing number of environmental and development problems such as water resources management are increasingly becoming complex and dynamic with greater degree of uncertainty. This paper employs a system thinking approach by developing a series of Causal Loop Diagrams (CLDs) to understand the challenges and complexity of water management in a developing country context. CLDs are used as a policy tool to highlight the critical linkages between various water system components. The paper highlights the dynamics of water system and proposes a case for sustainable management of water resources.

ii. Managing energy - irrigation conflicts through grievance redressal mechanisms (case study)

Aprajita Singh, Peoples Science Institute

Water use by hydropower projects in the western Himalayas has been known to often result in conflicts with local irrigation systems. We present here a case study from Uttarakhand that examines the results of introducing a platform to address grievances between the locals and the developers. Agriculture in Phalenda Village, Tehri Garhwal, suffered massive losses due to the damage done to their irrigation channels during the construction of the Bhilangana HEP. The establishment of Grievance Redressal Mechanisms can provide opportunities to local people to be able to negotiate settlements of disputes. Similarly, mediated negotiations between the HEP developers, irrigation department and the affected communities can help ensure sufficient irrigation water supply for the communities.

iii. Power tariffs for groundwater irrigation in India: A comparative analysis of the environmental, equity, and economic trade-offs

Balsher Singh Sidhu,
IRES, University of British Columbia

This paper is a comparative analysis of two widely used power tariff modes for charging agricultural groundwater consumers in India. Specifically, we compared flat and metered tariffs in terms of their administrative burden on power utilities, equity between rich and poor farmers, and influence on farmers' consumptive behaviour. We found that since flat-rated systems do not require metering, they are economical for utilities compared to metered systems. While the groundwater-abundant eastern regions can benefit from a hybrid flat-cum-metered tariff that encourages farmer-to-farmer water sales, western states facing unsustainable groundwater exploitation should develop tariff policies that ration power, prioritize its supply during the most critical seasons, and reward farmers who reduce their groundwater consumption.

Fig 39: Water-Energy-Food Nexus Governance session in progress.

21. Water Issues, Assessing and Meeting SDG 6

i. Water security assessment and SDGs

Sudeh Dehnavi, TH Köln – University of Applied Sciences

As part of the Sustainable Development, water security is included in the post 2015 development agenda. UN-water has set water security on the agenda of the UN Security Council. Different countries had adopted water security as an important pillar of their high-level principles of national strategies, policies and development plans referring to the UN- water definition . However, the UN Water definition for water security leaves space for a wide range of interpretations. Countries assign different weights to components of this definition based on their priorities and needs. Still, enable to process in line with achievement of the sustainable development goals by promoting certain components and undermining other aspects. The right recipe components to achieve water security in its sustainable form remains a topic to debate. This paper aims at finding country priorities for water security components and the triggers.

22. Agriculture and Water

i. Demonstration of novel framework for surface water management at agricultural catchment level- sustainable & technological approaches for pollution control

Shivaraju Puttaiah, JSS Academy of Higher Education & Research

Surface water management at agricultural catchment level is one of the challenging and most difficult tasks due to the multidimensional and nonpoint contamination sources. Contamination of surface water by various emerging pollutants released from agricultural and urban catchment region has drastically increased due to difficulties in identification of contamination type and sources. Self-sustaining remediation techniques such as biofencing & low-cost (indigenous) adsorbents in bunding at agricultural catchments and decentralized wastewater treatment framework at urban catchments have addressed for sustainable catchment management and surface water conservation.

ii. 3-D crop architecture modeling: A new tool to achieve food security

Anurupa Das, Indian Institute of Technology, Madras

Rice is the staple food for more than half the world's population. In terms

of tonnage, rice tops the list of cereals produced in India, and it is the third most produced cereal of the world. The world's population is increasing at an average rate of 1.36 percent per year [FAOSTAT, 2002]. To cater the needs of the increasing population, rice supply should also increase. Our computational modeling technique can be advantageously applied to other major Indian cereal crops such as wheat, and maize and has the potential to significantly contribute to achieving food security in the future.

iii. Increasing the resilience of Indian agriculture to monsoon variability through optimized irrigation strategies

Balsher Sidhu, IRES, University of British Columbia

Rainfed agriculture occupies about 70% of the net sown area in India, making more than 500 million people engaged in this activity extremely vulnerable to variations in climate. Most previous studies analyzing the impact of climate change on agriculture have operated at seasonal timescales. They utilize seasonal average climate values, but those seasonal trends have a limitation. Our research will help improve management of India's agricultural water consumption while accounting for the impacts of climate change. It will shed new light on the effect that increasing intra-seasonal variability in climate can have on crop yields, which had hitherto been ignored in previous studies.

iv. A machine learning approach for agricultural water management to balance the effect of climate changes

Pradeep H K, JSS Academy of Technical Education, Visvevaraya Technological University

The agricultural water management systems are analyzed to determine the efficient irrigation system based on soil and land properties, investment cost and water productivity (WP). In case of investment constraint, the surface irrigation surpasses the drip and sprinkler irrigation method since micro-irrigation demand high initial investment and maintenance cost. This paper exhibits that water productivity (WP) significantly increases through irrigation automation using finite state machine model and machine learning techniques.

v. Data assimilation into land surface models: implications for terrestrial feedback

Indu Jayaluxmi, Indian Institute of Technology, Bombay

This study aims at evaluating the uncertainty in prediction of land surface fluxes from offline simulations from land surface model (LSM) forced by hydro-meteorological data. The LSM simulations are known to be highly sensitive to the meteorological forcing (particularly precipitation) and model uncertainties. This study aims at evaluating the uncertainty in prediction

of land surface fluxes from offline simulations from land surface model (LSM) forced by hydro-meteorological data. The LSM simulations are known to be highly sensitive to the meteorological forcing (particularly precipitation) and model uncertainties.

vi. Development of high-resolution multi-layer soil moisture information
Karthikeyan Lanka, Indian Institute of Technology, Bombay

Multi-layer soil moisture information at high resolution is necessary for the agriculture sector and also towards modelling extreme events, among other areas of research. In this work, we develop a high-resolution multi-layer soil moisture information over the Contiguous United States (CONUS) region. The CONUS has dense in-situ soil moisture station network comprising of 695 stations, which monitor soil moisture at multiple layers. The results are highly encouraging, indicating the validity of the proposed technique. Based on these results, we will now focus our efforts on improving the prediction accuracy of soil moisture in the deepest layers.

vii. Evaluation of satellite based ET0 models for all sky conditions
Shwetha Rangaswamy, Indian Institute of Science

In this study, radiation and temperature based ET0 models were evaluated with the FAO56 Penman Monteith equation over the Cauvery basin. Land surface temperature (LST) along with auxiliary data were employed in statistical approach to estimate Ta (max/min). Rs was obtained from the Kalpana1 satellite. Under clear sky conditions, Hargreaves-Samani (HS), Makkink (Makk), Penman Monteith Temperature (PMT) models were considered for the study region. This study has demonstrated the applicability of satellite-based Ta and ETo estimation over an Indian river basin that had not been examined previously.

Fig 40: Agriculture and Water session in progress.

23. Analysis of Groundwater Contamination

i. Arsenic in shallow Bengal aquifer: Large scale human-water interaction and suffering

Debashis Chatterjee, University of Kalyani

Groundwater is contaminated with geogenic As and exceeds WHO guideline value. Groundwater flow is slow and contributing for distribution pattern As. High As aquifer sediments are composed of grey silty sands, whereas low As aquifer sediments contain white /brown sand and are reducing in nature with more sediment–water interaction. High Fe contents of the sediment are associated with high As in groundwater. Groundwater is predominantly reducing conditions at near-neutral pH with high HCO3- along with redox sensitive species and low concentration of SO42-, NO3-, DO. Another major challenge is As in food-chain. Bioaccumulation needs proper attention to regulate policy. Increased risk of As contamination is a challenging issue, risk has to be minimized. Aquifer mapping is necessary to delineate safe aquifer for drinking water supply, which will comply with the health-based guidelines for a long-term basis.

ii. Geochemical characteristics of groundwater in Wilgamuwa Region, Sri Lanka

Hashini Amaratunga, PGIS – University Of Peradeniya

Chronic Kidney Disease of unknown etiology (CKDu) is a most controversial health issue that is scattered in a certain geographical area in the dry zone of Sri Lanka. This study was aimed to determine the involvement of possible hydrogeochemical factors on the onset of the diseases. Wilgamuwa region is a CKDu hot spot that located in the dry zone of Sri Lanka was selected for the study. Sixty-five (65) groundwater samples were collected and analyzed for their major and trace element constituents.

iii. Analysis of bacteriological quality of domestic water sources in Kabale Municipality, Western Uganda

Alex Saturday, Kabale University

The study assessed the bacteriological quality of water sources in Kabale Municipality. Most water sources located in less than 20 meters away from residential areas were associated with bacterial contamination. The mean concentrations of E. coli, total coliforms, and THB were 24.07 CFU/100 ml, 85.71 CFU/100 ml, and 197.07 CFU/100 ml, respectively in the wet season. In the dry season, the mean concentrations were 2 CFU/100 ml, 10 CFU/100 ml, and 91 CFU/100 ml for E. coli, total coliforms, and THB respectively. This showed significant differences between CFU of total coliforms, HTB, between wet and

dry seasons (p = 0.026).

iv. The challenges of water quality survey in North-eastern part of India
Dhiraj Dutta, Defence Research and Development Organization

There cannot be an argument about the requirement of water for whole human life. Also, it's been established well that the quality of water required for survival of living beings especially for humans is getting deteriorated day by day. Therefore, water quality survey and source evaluation are of constant need for any society. Lot of water quality survey is being taken by various agencies on time to time basis. DRL Tezpur is constantly working on water quality survey in North East India. Detail survey works within North East India, is carried out with collection of water samples as per WHO guidelines. Characterization is carried out as per IS 10500:2012 Indian Standard of Drinking water It can be concluded that Iron, Arsenic, Fluoride and microbial contamination are the major threat in the North East India.

v. Determination of ppb level of Arsenic in environmental samples by nanosensor Boron doped carbon dots
Fahmida Khan, National Institute of Technology, Raipur

High concentration of arsenic in the body is dangerous for health because it inactivates up to 200 enzymes which are involved in cellular energy pathways. So, their detection is important in a simple way. For this purpose, we have synthesized a simple and low-cost photoluminescence sensor of Boron-doped carbon dots by one step pyrolysis method. B-CDs based fluorescence sensor was used for selective detection of As(III) ion by using quenching properties of fluorescence intensity of the sample. The fluorescent-based sensor B-CDs can be stored for a long time for detection applications. The detection limit is 0.01 ppb, for the B-CDs.

24. Case Studies of Water-Energy-Food Nexus Solutions and Implementations

i. The energy-water nexus in dryland agriculture: a case study of southern India
Pawan Wable, ICRISAT

Water and energy are the important available resources which need to be optimized for achieving ecosystem sustainability. This study quantifies the irrigation water needs and energy consumption in different cropping system in one of the drought-affected mesoscale watershed, Chikkamagaluru, Karnataka, southern India. The automatic divers, which measures water pressure, are installed at eight agricultural fields capturing different cropping system. This study aims to quantify the irrigation water needs and energy consumption in different cropping system in one of the drought-affected mesoscale watershed,

Chikkamagaluru, Karnataka, southern India.

ii. WEIFF: Water and energy integrated farm factory

Bhargavi Tadipatri, Vijaya College, RV Road, Bangalore

WEIFF anticipates potential trade-off among resources, governance, infrastructure, resilience, water, energy, health and sanitation. Hydrological units are created with wastewater treatment that is vital for WEIFF. WEIFF uses hydroponics and solar energy. A study in Bangalore reveals that metal contamination is heavy in vegetables. Tomatoes are taken as hydroponic crop for illustration. It is a lean canvas for ideation, formation, commercialization and market capitalization. The Water-Energy-Food Nexus (WEFN) is a multifaceted approach. WEFN elements cannot be isolated for decision making to strengthen ecosystem that resilient to climate change. The study seeks to points WEFN indicators as parameters to meet present and future societal demands related to water and food security.

iii. Sustaining food production and conserving hydropower potential in China

Hong Yang, Swiss Federal Institute of Aquatic Science and Technology

Water–food–energy (WFE) nexus has been widely discussed in recent years amid the needs for formulating pathways towards sustainable agricultural production and energy supply. However, knowledge regarding the WFE nexus is still largely lacking, particularly beyond the conceptual description. In this study, we combined a grid-based crop model with a hydropower scheme based on the Distributed Biosphere Hydrological model to investigate the WFE interplays in China. This study combined the PEPIC crop model with the DBH hydrological model to investigate the WFE nexus in mainland China under various irrigated cropland scenarios.

iv. Hydropower in the Mekong: the food, energy and water nexus

Jamie Pittock, The Australian National University

Low-emission hydropower production and agricultural intensification are two solutions promoted by governments for sustainable development in a resource constrained world. The rapid development of hydropower in the Mekong River basin has been portrayed as a simple trade-off between low carbon energy generation versus freshwater fisheries of importance for biodiversity conservation and food supply. Basin governments have prioritised hydropower production over fish conservation. This work identifies trade-offs in the energy, water and food nexus in the Mekong region where hydropower development and agricultural intensification is accelerating.

v. Nexus modelling to inform robust water management climate change adaptation

Andrea Momblanch, Cranfield University

Climate change is a threat to future water security and, thereby, political action is needed to adapt to its uncertain impacts. The joint use of systems modelling, robust decision making and water-food-energy nexus with a stakeholder-driven approach serves as generalised tool for the design of water management adaptation measures that are robust across multiple water uses and climate futures. The combined use of water resource systems models with robust decision making and water-food-energy nexus approaches supports the design of water management adaptation measures that ensure water security under future climate change uncertainty.

25. Groundwater Quality and Assessment II

i. Village level hydrogeological, remote sensing and lineament mapping for sustainable groundwater development - Case study in a severely water stressed area in hardrock terrains of Southern India

Dr. S Srinivasa Vittala, Central Ground Water Board, Ministry of Jalshakti

The study has been carried out to pinpoint the practically best fitted feasible sites to take up groundwater exploration at village level which can cater drinking water needs in a severely water stressed Bendoni village located in Koratagere taluk of Tumkur district, Karnataka state, one of the hard rock areas in part of Southern India. The scientific field hydrogeological survey and lineament mapping using high resolution satellite data have been carried out to decipher sub-surface hydrogeologic conditions and pinpoint the sites for detecting groundwater potential zones at village level especially in hard rock terrains where shallow aquifer are over-exploited. The initiative is taken up by Central Ground Water Board, Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India under prestigious project 'National Aquifer Mapping and Management Programme (NAQUIM).

ii. Impact of mission Kakatiya on groundwater regime and socio-economic status - A case study from Pedda Cheruvu, Chepur village, Armoor mandal, Nizamabad district, Telangana State

Samineni Indumathi, Telangana State Ground Water Department

In order to enhance the development of agriculture based income for small and marginal farmers, Government of Telangana has taken up the

comprehensive programme for restoration of ~46500 minor tanks under "Mission Kakatiya" with a tag line of "Mana Ooru Mana Cheruvu" in phased manner and so for grounded about ~27700 tanks (up to 4th phases) and stabilized > 5.6 lakh acres ayacut. As a part of these activities, the State Groundwater Department carried out the impact assessment studies on groundwater regime. The studies on improvement on groundwater regime in influence and non-influence zone, agriculture extent, cropping pattern, yields and socio-economic status etc were carried out in Pedda Cheruvu (tank), Chepur village, Armoor Mandal of Nizamabad district, which is part of an overexploited Chepur basin. These studies reveal, a net fall of 4.6 m, net rise of 12.6 m and again a net fall of 3.4 m in groundwater levels during post-monsoon season as compared to pre-monsoon season of these 3 years with average rise of 2 m/year during this period. Increase in irrigated area from 53 ha during 2015-16 to 118 ha and 66 ha during the next 2 years is noticed. Decrease in gap ayacut by 38 %, increase in irrigation intensity to 70 % and 39 % is noticed.

iii. Mapping of fractures and groundwater pathways in hardrock by heliborne geophysics

Subash Chandra, CSIR-National Geophysical Research Institute, River Basin Governance

A pilot study on aquifer mapping employing heliborne geophysical (electromagnetic and magnetic) methods in granitic hard rock terrain led to the development of an approach to map large scale fractures and groundwater pathways using transient electromagnetic (TEM) data in combination with geological and borehole information. Due to the sensitivity of TEM signals to conducting bedrock fractures filled with water, the airborne TEM survey is found to be a potential tool for groundwater studies in hard rock terrains. A novel approach is developed to map major fracture networks that contain significant amount of water. The concept of threshold groundwater horizon helps in improving the success rate in terms of high yielding potential borewells. The study also helps in the identification of suitable zones to construct artificial recharge structures.

iv. Groundwater management in semi-arid area: A case study from Tumkur, Karnataka, India

Abhilash Paswan, CSIR-NGRI

Groundwater has reached at a critical level in many parts of India especially in hard rock terrain. Understanding of its current state and proper management is utmost important. Keeping this in mind, a Decision Support Tool for Groundwater Water (DST-GW) management has been developed and implemented successfully using both hydrogeological and climatic data from 2011-2013 over Tumkur watershed in Karnataka to understand the temporal groundwater resource evolution. The DST-GW simulations show an alarming decline of groundwater level exacerbates by intensive pumping. This simple but novel tool allows to highlight crucial resource issue in a near future and recommends an urgent sustainable management.

i. Exploring an alternative approach to inter-state basin governance: The case of Mahanadi Basin, India
K J Joy, Society for Promoting Participative Ecosystem Management (SOPPECOM)

The proposed interlinking of Ken and Betwa rivers is based on the concept of surplus and deficit. A review of feasibility and detailed project report of the proposed project indicated the ambiguity in the definition of surplus and deficit. In addition, groundwater, being one of the important resources in the region, has not been a part of discussion in the proposal documents. This study explored compares two basins using geomorphological, climatological and groundwater resource aspects. The study suggests that similar studies should be carried out for other interlinking proposals to clarify the definition of surplus and deficit basins. In addition to this assessment, there is need to look into Temporal dimension for establishing surplus and deficit.

ii. Exploring surplus and deficit criteria for Ken-Betwa river interlinking project
Ritambhra Thakur, Tata Institute of Social Sciences

The proposed interlinking of Ken and Betwa rivers is based on the concept of surplus and deficit. A review of feasibility and detailed project report of the proposed project indicated the ambiguity in the definition of surplus and deficit. In addition, groundwater, being one of the important resources in the region, has not been a part of discussion in the proposal documents. This study explored compares two basins using geomorphological, climatological and groundwater resource aspects. The study suggests that similar studies should be carried out for other interlinking proposals to clarify the definition of surplus and deficit basins. In addition to this assessment, there is need to look into temporal dimension for establishing surplus and deficit.

iii. Development for transboundary water governance: Application of serious games in multi-stakeholder dialogue
Mahsa Motlagh, Institute for Technology and Resources Management in the Tropics and Subtropics (ITT) at Cologne University of Applied Sciences

Cooperation over transboundary waters is one of the primary pillars for achieving local, national and international water security while acts as capacity building instrument to boost political, social and economic cohesion by contributing to the regional peace and stability. The sustainable governance of water resources relies on multi-stakeholder

Fig 41: River Basin Governance session in progress.

cooperation and communications that facilitate information sharing, knowledge co-creation, and social co-learning. The objectives of this contribution are: - To present role-play game experiments as a stakeholders' skill-building and joint solution seeking approach to providing the enabling platform for knowledge-sharing, transparency, and confidence-building among them. -To build an understanding of the complexity of shared water management and security risks among involved stakeholders and actors.

iv. Water Conflict Vulnerability and Stakeholder Engagement in Water Resources Planning Kangkanika Neog, Council on Energy, Environment and Water, New Delhi

Water Resource Planning and Management encompasses activities like planning, developing, and managing the quantity and quality of water resources among all water users. However, with the increasing understanding of limitations on water supply and growing demand, several reformulation of water resource planning methods globally. Our research takes a step-back from the traditional method of water resources planning and delves into these new paradigms. The study recommends inclusion of water conflict vulnerability assessment and stakeholder engagement over and above the traditional linear water resource planning as it exists now.

27. Water Security in Agriculture and Adaptation to Climate Change

i. Water pricing system in Kerala: Sustainable or not?
Anitha, Department of Economics, University of Kerala, Thiruvananthapuram

Even though the availability of water is plenty in Kerala during monsoon season, the state faces severe water shortage during the summer season. It leads to unfair practices in the supply of water and denied accessibility to particular sections. The private water supply agencies(mushrooming during summer season) charges huge prices whereas the public supply of water in Kerala charges only nominal and volumetric price. The study suggests that in order to reduce the effects of full cost on the social welfare of society, we may apply Lindahl's pricing principle. That is those who use more water pays more (telescopic pricing system). This may reduce the burden to the lower sections of society.

ii. Satellite based evidences of shifting in irrigation practices over Punjab and Haryana
Dharmendra, Haryana Space Applications Centre

Due to over-exploitation of water storage components (mainly includes ground water resources) it faced great depletion in Indian during the last two decades as reported by Rodell et al. (2009). In response to this, Punjab government has implemented an Act called the Punjab Preservation of Sub Soil Water Act (2009) for water conservation. Effectiveness of the Punjab Preservation of Sub Soil Water Act (2009) is investigated by assessing the shifting in irrigation practices over Punjab and Haryana states of India using satellite measurements during the year 2002 to 2011. Three parameters namely, soil moisture, Normalized Difference Vegetation Index (NDVI) and Evapotranspiration (ET) have been used.

iii. Irrigation adaptation due to water scarcity
Nandeesh R V, Bangalore University

Drying of the water resources and depletion in the underground water has caused a serious problem in the agriculture so certain new adaptation in irrigation has been taken place in order overcome the drought and water scarcity problem. The study deals with the new technological adaptations in the irrigation method to face water scarcity.

iv. Trading water: quantifying inter-state trade of cereals in India
Francesca, London School of Hygiene & Tropical Medicine

Depleting groundwater reserves are a major risk for future agricultural production in India. Inter-state cereal trade could reduce unsustainable water use if cereals move from water abundant to water scare

states. The study explores the water use of India's food system through the production, trade and demand of cereal crops. Cereal production and demand were linked using an optimization model of interstate food trade .The study examine the influence of inter-state trade on agricultural water use and relate this to the challenge of ensuring sustainable food systems in India.

v. Bridging water supply-demand gap in dryland agricultural production systems to maximize economic water productivity Vinay, International Center for Agricultural Research in the Dry Areas (ICARDA)

Dry areas are home to large populations of the world. Food production and healthy living is a major challenge in dry areas because of low and erratic rainfall, high temperatures causing high evaporative losses and soils that are poor in nutrient and water holding capacity. ICARDA, in partnership with national institutions across India, has researched solutions to address these challenges. The study examines best-management practices to address the water demand-supply gap in dry areas of India to maximize economic water productivity in different agricultural production systems.

vi. A Critical sectoral assessment of the effectiveness of economic instruments in improving water use efficiency Sridharan Ashwin Ram, Madras School of Economics

Water is essential and exhaustible natural resource that is fast depleting due rapid population growth and climate change. There is a growing consensus among global development community that water security is increasingly becoming one of the biggest development and environmental challenge of the century next to climate change. Predominant efforts towards the supply and allocation of water resources resulted in inefficient usage across different sectors leading to water scarcity. The paper particularly focusses on studies that deal with the applications of EIs such as price, tax and subsidies to improve Water Use Efficiency across agriculture, industrial and domestic sectors.

28. Water Security, Informal Water Use and Water Access

i. Mapping water scarcity in India using Water Poverty Index

Ashish, Indian Institute of Science

Water as a basic natural resource plays a very important role in the economic, ecological and human development of any country. Water in India is a state subject and the provision of a reliable, safe and sustainable supply of water has emerged as a challenge due to geographical and institutional constraints of water resources. Other than physical availability, the financial and institutional limitations also lead to poor performance of the water sector in India. The study tries to map water scarcity in India using Water Poverty Index (WPI). This study aims to amplify the importance of multidimensional analysis of water scarcity in India, where challenges and constraints of water resource management changes within states.

ii. Impact of neoliberalisation of urban water supply on the urban poor in the slums of Rasoolpura, Hyderabad

Shreya Karmakar, Foundation for Ecological Security

Water as a basic natural resource plays a very important role in the economic, ecological and human development of any country. Water in India is a state subject and the provision of a reliable, safe and sustainable supply of water has emerged as a challenge due to geographical and institutional constraints of water resources. Other than physical availability, the financial and institutional limitations also lead to poor performance of the water sector in India. The study tries to map water scarcity in India using Water Poverty Index (WPI). This study aims to amplify the importance of multidimensional analysis of water scarcity in India, where challenges and constraints of water resource management changes within states.

iii. Living in a city built by private firms: Water and vulnerability in the millennium city of Gurugram

Suparna Chatterjee, Young Bhartiya Foundation

The water crisis around the world is tipping, and the research here has aimed to examine the nature of water crisis as perceived by the urban poor in a situation when the public delivery system fails to deliver services to them especially to the migrants who work within the informal sector. It also looks at the implications the development of informal water markets has for the inequality in water supply and also on the coping strategies adopted by the vulnerable groups of population.

iv. Integrated exploration, analysis and improvements

to water based institutional mechanisms in informal settlements of India
Priyanjali Bose, Megh Pyne Abhiyaan

Urbanization has sped up the migration of millions into informal settlements or unregistered slums located in major cities. Municipal corporations provide formal water connections to inhabitants residing in their own land. Whereas absence of water right provisions for informal slums devoid them of hydrological empowerment. The research will recommend best practices and improvements of such existing institutions for informal slum settlements. The study provides a means to clearly segregate suitable informal water institutions from the resource consuming ineffective ones. Such effective institutions should be broadly promoted for implementation. The methodology also helps isolate institutions which are poorly run but are otherwise highly promising in nature.

v. Fetching Water and Gender Dynamics in Indian Households
Manisha, International Institute for Population Sciences, Mumbai

Water is the most crucial need of mankind and a right for every human being. In India, traditionally it is the job of women to fetch water. More than 50 per cent of households fulfills their need for water from a source that is outside their houses in India. The average time taken for fetching water in one trip is 19 minutes at the national level and many trips required in a day for collection of water. This study examined the variation for the time taken and who is mainly responsible for collecting water across states of India and gender division of labour in water collection.

vi. Water In the World We Want: Canada´s Journey
Corinne, Robert Sandford, University of Saskatchewan

Canada has a reputation globally for being a water-rich country. However, amounts and timing vary across the country and are becoming far less predictable through the impact of climate change. Many river basins, particularly in mountainous regions are transitioning from snow-driven to rain-driven hydrological regimes. Economic activity, including legacy nutrients from agriculture continue to affect water quality. The goal of this paper is to highlight innovations in research and governance that can contribute to changes necessary to achieve local water security for all in Canada.

Fig 42: Water Security, Informal Water Use and Water Access session in progress.

29. An Integrated Global Vision for Water Security: Approaches and Methods

i. Experiences and definitions of water security by mountain communities
Shrinivas Badiger, ATREE, Bangalore

Water security here is studied through the presence or absence of water associated institutions which provide domestic water. Access to such institutions would be studied with respect to socio-economic factors and spatial location of the communities. This study is being done in the mountain town of Darjeeling of the Eastern Himalayan Region of India which brings in altitude and pattern of urbanization as additional drivers. This study will look at entitlements with respect to water security.

ii. Knowledge to action in Canada's Global Water Futures project
Lawrence, University of Saskatchewan

Global Waters Futures is a $144 million consortium of 4 major Canadian universities and the Canada First Research Excellence Fund. Its goal is to deliver risk management solutions (informed by leading-edge science and supported by new decision-making tools) for changing water futures in Canada and other cold regions of the world. One of its core objectives is to mobilize knowledge for action on water futures among over 100 researchers and 350 diverse end-user partners. This paper provides an early-stage narrative of approaches and outcomes in knowledge mobilization. It presents the conceptual framework adopted to guide the knowledge mobilization strategy and considers researcher attitudes and needs revealed through interactive, web-based surveys at scientific meetings.

iii. Rethinking training for water: Towards the African water vision and the SDGs
Christopher Gordon, University of Ghana

This paper responds to the cross-cutting theme of Capacity Building as well as several other topics and subtopics being presented at Waterfuture 2019. The achievement of the 17 Sustainable Development Goals and the Africa Water Vision 2025 –requires a new approach to the training of water researchers and water resource managers. We are proposing an innovative, flexible and responsive approach to graduate level training that could be delivered as short courses or in the form of a series of webinars, we propose a design of a series of standalone modules that participants identify as needed to complete an aspect of their education or professional competence.

iv. Prospects for future water availability in Peninsular India
Gwyn Rees, Centre for Ecology & Hydrology

Rapid economic development and population growth in Peninsular India and the associated urbanization, deforestation and agricultural intensification, which has resulted in shifts between rain-fed and irrigated crops and a widespread proliferation of small-scale surface-water storage interventions, such as farm-level bunds, ponds and check-dams, and groundwater abstractions, have contributed significantly to changes in the hydrology of catchments and are seriously affecting water resources.

Fig 43: An Integrated Global Vision for Water Security: Approaches and Methods session in progress.

i. Societal awareness and water learning as adaptive water management strategy in water stressed areas

Aju CD, Karyavattom Campus, University of Kerala

Many parts of the Kerala experiences water crisis in the aftermath of heavy rains. The proper management of excess runoff water is necessary to alleviate the water scarcity problems. The objective of this study is to identify the water stressed areas and to give social awareness for possible adaptive water management methods. . The study highlights the need of water management in panchayath level in water stressed areas of Kerala and the importance of social learning as well as awareness programs to enhance excess run off recharge through economically feasible small-scale recharge structures. The study area is a part of the Kallada river basin in the Kollam district of Kerala.

ii. Human Arsenic exposure risk via crop consumption and global food trade

Karen Villholth, IWMI, International Water Management Institute

Arsenic in the food chain, from crop production in groundwater-contaminated areas and through trade, is a potential source of human exposure risk. Using global datasets on crop production, global trade, irrigation and arsenic contaminated groundwater hazard, we estimate that 1.5 billion people may be exposed to significant arsenic dietary risk through stable crops of rice, wheat, and maize. With growing food requirements, increasingly globalized food trade, intensifying climate variability and associated likelihood of expanding groundwater irrigation into contaminated regions of the world, predominantly presently rainfed regions in tropical and semi-tropical regions, the enhanced risk to human health from arsenic exposure in food and via trade requires further attention. This study tries to explore the human arsenic exposure risk via crop consumption and food trade.

iii. GIS-Based spatial distribution of groundwater quality and regional suitability evaluation for drinking water

Archana Sarkar, National Institute of Hydrology, Roorkee

A geospatial based water quality index is developed for preparing water quality class suitability map to provide an overview of the spatial variation of groundwater quality parameters, i.e., Fluoride (F), Nitrate (NO3), Chloride (Cl), Total Dissolved Solids (TDS), pH and Total Hardness (TH) in the Khushkhera - Bhiwadi - Neemrana Investment Region (KBNIR). Groundwater samples were collected from 14 locations, tested

in the laboratory and analyzed using Geographical Information Systems (GIS) technology. This paper presents integrated approaches to characterizing the spatial distributed hydrochemistry and hydro-chemical suitability of groundwater for drinking properties in the KBNIR, Rajasthan.

iv. The costs and benefits of managed aquifer recharge Andrew Ross, Australian National University

The financial and economic performance of MAR is a key determinant of its global uptake, but there are few studies that leverage outstanding sustainable examples of MAR and demonstrate its financial and economic benefits. IAH MAR is addressing this deficit through a two-stage research program to document the financial costs and economics of MAR in relation to alternative water supplies or storages. This study presents an analysis of costs and benefits of over 30 MAR schemes from over 10 countries.

31. Interlinkages in Urban Water Systems

i. Old wisdom for new resilient smart cities : An introspect for SDG 6 Akash Sondhi, TERI School of Advanced Studies

Urbanization in India, has resulted in large stress on its supporting natural resources and especially water resource and reserves. Development has resulted in modified urban hydrology, large water consumption and associated wastewater discharge. Often grim scenarios exist such as the dead and dying lakes of Hyderabad and the ill-fated Bellandur lake catching fire in the mega city Bangalore and the anaerobic rivers adjoining New Delhi. This paper aims at appreciation of the advantages of the revival of creative water systems from the past in 21st century to increase the resilience of the urban ecosystems towards climate extremes. It also aims at providing a workable perspective to the policy makers to and share new paradigm in legal norms towards sustainable urban water management.

ii. Sanitation in future cities: Groundwater and sanitation interlinkages in peri-urban Bangalore Durba Biswas, Ashoka Trust for Research in Ecology and the Environment

Many peri-urban and emerging towns are poised to become the ‘future cities’. In peri-urban towns, on-site sanitation systems (OSS) along with solid waste disposal, agricultural pollution, and livestock waste disposal are all potential sources of water contamination. We use an interdisciplinary approach to map out social creation of pollution from multiple sources. This can be a potential roadmap to achieve the twin goals of universal sanitation and access to safe domestic water.

iii. Observation of the impact of urbanization on precipitation trends in India
Hiteshri Shashtri, Charotar University of Science and Technology, Gujarat

The urban areas in India have experienced an unprecedented rate of growth over last few decades. This study examines how urbanization affects the precipitation climatology of Indian Summer Monsoon Rainfall (ISMR). An investigation is carried out to evaluate explicit changes of ISMR around all the major urban centres of India. The trends observed in selected precipitation indices reveal large degree of spatial inter-variability over the country. At the same time, the results indicate a greater degree of inclination for occurrence of changes under regions of urban influence. The study evidently points out influence of urbanisation over amendments in the regional rainfall pattern in India to a convinced extent.

iv. Integrated urban water and energy balance for urban planning
Mayank Gupta, Indian Institute of Technology, Bombay

Urban areas occupy less footprint but contribute largest to GHGs. In addition, the positive feedback loop in vulnerability between climate change and cities poses risk to human health and well-being. The objective of the study is to understand urban feedback through integrated urban energy and water balance and assess the potential of mitigation measures to lower air temperature for human comfort. The urban heterogeneity is evaluated through Local Climate zones (LCZ) classification scheme. The study uses surface atmospheric parameterization approach to assess spatial and temporal heterogeneity in energy and water balance profiles of a city. Urban areas occupy less footprint but contribute largest to GHGs. In addition, the positive feedback loop in vulnerability between climate change and cities poses risk to human health and well-being. The objective of the study is to understand urban feedback through integrated urban energy and water balance and assess the potential of mitigation measures to lower air temperature for human comfort. The urban heterogeneity is evaluated through Local Climate zones (LCZ) classification scheme. The study uses surface atmospheric parameterization approach to assess spatial and temporal heterogeneity in energy and water balance profiles of a city. Urban areas occupy less footprint but contribute largest to GHGs. In addition, the positive feedback loop in vulnerability between climate change and cities poses risk to human health and well-being. The objective of the study is to understand urban feedback through integrated urban energy and water balance and assess the potential of mitigation measures to lower air temperature for human comfort. The urban heterogeneity is evaluated through Local Climate zones (LCZ) classification scheme. The study uses surface atmospheric parameterization approach to assess spatial and temporal heterogeneity in energy and water balance profiles of a city.

i. Water resources management for inclusive development of the society
Pramod Kumar, SM
Government Girls High School, Puri, Odisha

The Analysis of water quality of the country carried out by central pollution country Board (CPCB)with respect to the biochemical oxygen demand (BOD) and the content of pathogenic bacteria reflects a gradual degradation of water quality of the country over time. It is mainly due to inappropriate disposal of wastes and its mismatch with the cleaning facility and natural reviving capacity of the environment. A large number of water bodies are identified as polluted stretches and come under Ganga Action plan and National River Action Plans. Appropriate measures to restore their quality are undertaken in these programs. The Groundwater quality at deeper aquifer however varies from place to place. Localised incidence of salinity arsenic, fluoride and iron content have surfaced mostly due to geo-genic influence except coastal salinity. Occurrence of heavy metal ions have also been observed in some ground water aquifer in industrially active areas.

ii. Examination and remedial action on water quality of Rajgangpur, Odisha
Sarojini Sahu, Gopabandhu Government High School, Rajgangpur, Odisha

Rajgangpur is an industrial town of western Odisha. It lies in the mineral belt of limestone and dolomite. So, there is probability that compounds of Calcium and Magnesium may affect the underground water quality of this town. Hence an experimental study is conducted on the underground water quality and water supply by the Public Health Department. Total 16 numbers of water samples were collected from different areas of Rajgangpur town, out of which 14 samples are underground water and 2 samples are partially treated river water.

iii. An Integrated approach to manage overexploited aquifers of Semi -arid region, NCR, India
Rina Kumari, Central University of Gujarat, Gandhinagar

Millions of people in this region rely on groundwater for fulfilling daily water needs due to lack of public water supply and infrastructure. Inadequately controlled pumping to meet daily requirements has affected both groundwater quantity & quality in these regions. One such region is the National Capital Region (NCR) of India. The study analyses major ions and stable isotopes to describe the composition and distribution of saline groundwater, fluoride enrichment and

other geochemical processes in the area. The results lead to the conclusion that geographical characteristics of the region, surface water and groundwater influx into the poorly drained semiarid basin, results in the accumulation and release of salts in groundwater as well.

iv. Remedies for bacterial contamination of Jiya Bharali River by using modified river sand

Swagata Goswami, Defence Research and Development Organization

Managing water resources in Arunachal Pradesh in effective manner implies ensuring sustainable utilization of the immense water resources of the State. The main objective of the National Water Mission (NWM) is “conservation of water and water resources development and management. Our study is based on evaluation of Nano composite in reducing bacterial load. Soil which can be found locally is coated with Silver (Ag+) using Silver nitrate, the least expensive form of silver. The antibacterial activity of Silver coated soil is tested against E. Coli isolated from wastewater which is a predominant bacteria in the water world. The test results were positive for our experimental work. It can be concluded that Silver coated sand can be used in water filters for bacterial purification.

v. Removal of Cadmium and Lead from aqueous solution by Hydroxyapatite/ Chitosan hybrid fibrous sorbent

Debabrata Bhadra, Bhairab Ganguly College, Belgharia, Kolkata

Hydroxyapatite (HAp)/chitosan composites were prepared by a coprecipitation method, dropping a mixture of chitosan solution and phosphoric acid solution into a calcium hydroxide solution. Using the HAp/ chitosan composites prepared, HAp/ chitosan hybrid fibres with various HAp contents were prepared by a wet spinning method. X-ray diffraction and scanning electron microscopy analyses were conducted. It was observed that in particular, the removal capacity for the heavy metal ions increased with increasing HAp content in the HAp/ chitosan hybrid fibres due to the increase of the specific surface area.

vi. An overview on recycle and reuse of treated wastewater in industries

Shanmugasundaram O.L., K.S. Rangasamy College of Technology

This paper communicates an extensive research work carried out by various scientists on advanced treatment methods for recycle and reuse of wastewater in industries. Different technologies such as reverse osmosis, nanofiltration, ultrafiltration, carbon adsorption, electrochemical treatment, ozonation and combination of various treatment techniques were experimented on at pilot plant to test their efficiency in removing pollutants and to verify the possibility of reuse of treated wastewater in industries.

33. Water Ethics: Concepts and Approaches

i. Transforming water: Towards a life-affirming ethical approach to water management
Susan Smith, Willamette University

Premised on anthropocentric utilitarian ethics and a fundamentally, fatally flawed neoliberal economic model, SIWRM utilizes pluralistic consultation processes that cannot manage water sustainably in a world of severe wealth inequality and continuing marginalization of minorities. Most significantly, SIWRM fails miserably in providing all life with sufficient and healthy water. This paper demonstrates the inadequacies of the current water management paradigm and the desirability of replacing that paradigm with a life-affirming ethical approach to water management. LEAW can be translated into a pragmatic tool for water managers to take the next step toward better water management by assuring that water is shared equitably with all life. By drawing on principles of water justice and the natural water law known to and employed by indigenous peoples, water can be managed for the benefit of all.

ii. Exploring the water crisis in Uttar Pradesh
Pawan Kumar, Central University of Gujarat, Gandhinagar

This paper from a 'Interdisciplinary' perspective tries to examine the water crisis in UP, through a case study of 'Water Rights March' (WRM) (a rally held from Mehndiganj, Varanasi to Parliament, New Delhi, from 10th September to 05th October in 2006 in UP). It also tries to identify the challenges (nature of water crisis) and possibilities (solutions in the form of water consciousness) of sustainable water resources in UP. The main aim and objective of this study is to theorize, understand, and explore the relationship between abundance, scarcity, and water crisis in UP.

iii. Using ethics to clarify water values and create "the world we want"
David Groenfeldt, Water-Culture Institute

Participatory planning through multi-stakeholder platforms and scenario building constitutes accepted best practice, but an important step is still missing. To counter the bias of outside experts who prefer to be guided by economic measures that can be quantified and ranked, an ethics analysis of stakeholders' water preferences (values) may be required. This study will use cases from South and SE Asia and Western North America to show how ethics analysis can complement participatory planning measures. The methodology of the study involves stakeholder engagement (multistakeholder platforms and scenario-building) with new tools for identifying and prioritizing water values and ethics. This approach to "valuing the values" can inform the activities of the

newly created "Valuing Water Leadership Coalition" and related initiatives.

iv. "… Before, the floodwater used to come in gracefully and recede faster": Political ecology of the Brahmaputra Valley hazardscape and rethinking the postcolonial state

Mitul Baruah, Ashoka University

Based on ethnographic fieldwork, this paper examines the political ecological processes of the re-production of disastrous geographies in the Brahmaputra valley, Assam. The twin processes of flooding and riverbank erosion have defined the Brahmaputra valley landscape over the long haul of history, but they have now turned disastrous, resulting in steady loss of landmasses, large-scale outmigration of the local population, and devastation of traditional livelihood practices. The key objective of this paper is to advance theorizations of the (postcolonial) state in the context of geographies of disasters.

34. Water Quality Assessment: Case Studies

i. Analyzing microplastics in water systems: A case study of Negombo Basin Estuary, Sri Lanka

Ananya Shah, TERI School of Advanced Studies

The study has a three faceted approach comprising of Literature based comparison, quantitative analysis and characterization of MP present in the estuary., and the last being a qualitative risk and solution-based approach of the stakeholders of the estuary. Presence of Microplastics in surface water of our freshwater systems is a grave indication of risk to the water quality of these systems, which will eventually affect the whole ecosystem.

ii. Application of multivariate statistical methods to evaluate and adjust water quality monitoring network in Freiberger Mulde river basin, Germany

Thuy Nguyen, United Nations University (UNU-FLORES)/ TU Dresden

Cluster Analysis in association with analysis of violation of environmental quality standards under European Water Framework Directive allowed an exclusion of 37 monitoring sites and further reduction of 29 monitoring sites if in case of budget constraint. Principal Component Analysis identified predominant factors that influence the river water quality, including geological and weathering processes, mining activities, agricultural disuse pollution, and industrial activities. The results

illustrated the usefulness of multivariate statistical techniques in analysing complex WQ data set to improve the monitoring network in a resource-limited setting. The Saxon State Ministry of the Environment and Agriculture (Germany) can be directly beneficial from this study, not only in terms of monitoring cost but also a more representative monitoring network.

iii. Discovering linkages between catchment characteristics and water quality using catchment classification

Ankit Deshmukh, Indian Institute of Technology, Hyderabad

We develop a classification framework that can be employed to standardize classification exercises in hydrology. We stressed on two important aspects: the use of multiple classification methods and standardized performance metrics to gauge the success of a classification exercise. We compared clustering based on water quality metrics and clustering based on catchment characteristics to identify combinations of catchment characteristics that best explain water quality variations.

iv. Water quality at scale; Three demonstration cases on water quality and services in Africa

Kilian Christ, United Nations Environment Programme

Three examples in Africa, the Lake Victoria, the Volta basin in Ghana and the groundwater aquifers of Cape Town, serve as use cases to demonstrate the current capabilities and future information and services of the World Water Quality Alliance, a consortium coordinated by UN Environment of over 50 organizations working on freshwater quality. The use cases provide an initial testbed that puts the quality of surface and groundwater into the context of the local 2030 Agenda and its multiple linkages across the Sustainable Development Goals (SDG).

v. Investigating nitrate dynamics in a sub-tropical water reservoir using D17O method

Ritika Kaushal, Institute of Earth Sciences, Academia Sinica, Taipei

Feitsui Reservoir, the second largest freshwater reservoir of Taiwan, supplies water for more than five million people in Taipei. In view of processes controlling the long-term trophic status of this socio-economically and ecologically important reservoir, it is important to monitor the dynamics of nitrate, the most abundant phase of water-soluble nitrogen-bearing compounds. The study uses the 17O anomaly of nitrate dissolved in reservoir water as an effective method to quantify the vertical and seasonal variations in the concentrations of remineralized and atmospheric nitrate. The D17O method, along with other isotopic and physiological.

35. Groundwater Assessment and Agriculture

i. Deciphering the recharge of groundwater by Narmada canal irrigation, Gujarat

Raicy Mc, Physical Research Laboratory

Narmada Canal, which is one of the large irrigation networks in India is set up to recharge the over-exploited aquifer and to supply water for agricultural purposes in arid regions of Gujarat. The monitoring of variation in groundwater level and the understanding of isotopic signatures of water helps to assess the canal water-groundwater interaction in the area. Such a study is carried out here to assess the impact of canal water recharge on the groundwater behaviour along the Narmada canal. About 15 km buffer zones were selected on either sides of the Narmada canal including parts of nine districts (Ahmedabad, Mehsana, Patan, Banaskantha, Vadodara, Panchmahal, Gandhinagar, Kheda and Narmada) for detailed study. The groundwater levels in wells are found to be directly influenced by the recharge of irrigation returns facilitated by Narmada canal especially towards the central parts of the study area. Even though the changes in groundwater level gives clues to the influence of canal recharge on groundwater, the flow path of water beneath the surface and the mechanisms of exchange could be well understood by isotope characterisation of water.

ii. Assessing the processes governing solute concentration in groundwater: Insights from an irrigated semi-arid catchment

Buvaneshwari Sriramulu, Indian Institute of Science

Groundwater has become a vital resource since almost three decades in India. The use of groundwater for agriculture has grown exponentially leading to faster depletion than aquifer recharge. However, this particular use of groundwater for irrigation might pose a problem of declining groundwater volume and water quality degradation that are posing a risk to salinization. Groundwater solutes originates from various sources such as atmospheric inputs, water rock interactions and fertilizer residues. In pristine ecosystems, chlorine originates only from atmospheric inputs $[Cl]_{atm}$ and its degree of concentration in groundwater mostly depends upon the intensity of local evapotranspiration. For this reason, it is commonly used for quantifying groundwater recharge in catchment hydrology. In many agrosystems and particularly in Southern India, Chlorine [Cl] KCl is also brought as KCl through the potassium fertilization which is marginally taken up by plants as micronutrient and not interacting with aquifer minerals. Chlorine remains in solution and is likely to accumulate in groundwater as a result of the successive groundwater pumping/recharge cycles. This study proposes a novel method for assessing the sources and processes governing the groundwater concentration

in an irrigated semi-arid catchment.

iii. Irrigation draft estimation at village scale: A step towards microlevel groundwater management

Tajdarul Syed, Indian Institute of Technology (ISM), Dhanbad

According to recent estimates, draft for irrigation accounts for nearly 90% of the total groundwater withdrawn in India. This makes realistic assessment of groundwater draft at appropriate scale a necessity for planning of management interventions. While the available draft estimates serve the intended purpose of aiding in regional planning, they do not adequately represent the local variations, and neither can they be projected into the future. With this background the study was taken up with the objective to estimate and project groundwater draft at village level in the Seonath-Kharun Interfluve area covering around 3000 km2 in Chhattisgarh State. A larger objective of the study was to design and test a field-based method for realistic assessment and future prediction of groundwater draft, which can be applied to other parts of the country. This study demonstrates a method for the assessment and projection of groundwater draft utilizing readily available datasets and field surveys that can be replicated in other parts of the country.

iv. Sustainable groundwater management strategies for a wastewater irrigated agriculture system

Mahesh Jampani, United Nations University and Technical University of Dresden

Many agricultural landscapes in the developing world are irrigated with wastewater, and it is a livelihood practice in the urban and peri-urban areas. Farmers around urban agglomerations continuously depend on the wastewater released from nearby urban centres. While providing opportunities with respect to water and nutrient supply, irrigating with wastewater has adverse environmental impacts, particularly on the local aquifer systems. Therefore, addressing the wastewater irrigation influence on local aquifers becomes very relevant. The current research attempts to assess the contaminant fate and transport processes in the local aquifer under different wastewater application rates and qualities used for irrigation and to develop potential agricultural interventions and groundwater development strategies under irrigation management.

36. Solutions to Promote Sustainability in Water Space

i. Desalination by RO and multistage flash distillation as a solution to water crises and comparing both of them

Ujan Sengupta, Techno International New Town

Desalination is a separation process used to reduce the dissolved salt content of saline water to a usable level. All desalination processes involve three liquid streams: the saline feedwater (brackish water or seawater), low salinity product water, and very saline concentrate (brine or reject water).Reverse osmosis is a water purification technology that uses a partially permeable membrane to remove ions, molecules and larger particles from drinking water. The use of desalination overcomes the paradox faced by many coastal communities, that of having access to a practically inexhaustible supply of saline water but having no way to use it.

ii. Viable innovative methods for sustainable water future

Susmita Mohapatra, Government High School, Sector 16, Rourkela, Odisha

The scarcity of water is one of the most biting crises, thrust upon the world at social, economic, political and environmental levels. The adverse climatic change is making it more acute thwarting the efforts to provide adequate water to a growing population. The main impacts are on health, hunger, education and poverty; the reasons being large population explosion and lack of awareness of people, necessitating modernization, industrialization and deforestation, which ultimately affects the ecosystem. The current innovation of ADSORPTIVE SAND FILTER is most relevant for its simplicity, cost effectiveness and easy availability of ingredients. This filtration process can clean waste or polluted water for sanitation, ensure pure and safe drinking water, and make drinking water available for everyone and everywhere. This is mostly required to meet water crisis and check water pollution.

iii. Microbial electrochemical remediation system for removal of bioactive compounds from wastewater

Monika Sogani, Manipal University, Jaipur

Wastewater could be a potential water resource if appropriate treatment technologies could be developed. One of the barriers to obtaining high quality water from wastewater arises from the presence of organic micropollutants. Removal of these compounds from wastewater by current physio-chemical technologies is prohibitively expensive. Pollution of estrogenic compounds has caught the attention of researchers as the slight increase of oestrogens in the water bodies has a significant impact on the aquatic system. Two designs of microbial fuel cells including one with the

Proton Exchange Membrane(PEM) and the other one without the PEM were to be studied in reference to EE2 degradation, bioelectricity generation and hydrogen production as part of the process of nitrogen fixation.

iv. Integrated methodology for sustainable solutions to water related issues

Musarrat Parween, National Institute of Advanced Studies

The research project developed provides possible real-life social and technological solutions based on in-depth assessments of interventions in the water sector already made in terms of their impact, sustainability and scalability. The research has specifically addressed solutions that are technologically feasible, socially acceptable, economically viable and up scalable. In order to achieve the above-mentioned objectives a comprehensive, multidisciplinary and interdisciplinary research methodology was adopted.

v. Experimental study on domestic solar still desalination with cotton gauze

Baskaran V, Pondicherry Engineering College, Puducherry

Increase in population of mankind, is among the main cause for the climatic changes. This climatic change also accounts for the reduction in normal rainfall and thereby reducing the surface and sub-surface water sources leading to water scarcity to all the living beings existing on this earth. Here we are using solar energy to meet the daily water needs of coastal region. The objective of the study is to design a Solar Still based on location type, quality of saline water, availability of efficient materials and economics and to develop a socio-economic understanding of the coastal region.

vi. Economic valuation of ecosystem services: A case of Veli wetland system in Kerala

Resmi Panicker, Government College, Trivandrum

The human shocks like, rapid urbanisation, industrialisation and development of tourism activities poses severe threat to the conservation of ecosystem. The pre-set study tries to illuminate the economic value of ecosystem services provided by the lake ecosystem situated in Thiruvananthapuram city. The study reveals that due to adverse human action, the ecosystem services in Veli is in great danger. The Lake has got polluted in three ways. i.e., huge industrial waste from nearby industries, sewage waste and disposal of plastic waste from tourism activities.

vii. Influence of aridity on basin characteristics in the Budyko Framework

Anamitra Saha, Indian Institute of Technology, Bombay

Traditionally, in the Budyko framework, the basin characteristics parameter is assumed to be independent of climate variables and altered only by land use change and human activities. In our study we show, both experimentally and analytically, that the assumption of constant basin characteristics parameter and changing aridity in classical Budyko framework cannot fully explain the hydrometeorological impacts of climate change. The basin characteristics itself is influenced by aridity.

37. Technology-based Solutions in Addressing Water Quality

i. A low cost real timelow-cost real-time nitrate sensing system using mobile Apps

Darsana S, Institute of Human Resources Development, Kerala

Recent floods in our state, Kerala has contaminated all drinking water sources. Lack of facilities to monitor water quality was a problem faced by common people. Public Health department conducted only sample testing for E. coli and chlorine that too colorimetric. If people want to check their well water, they have to carry it to regional laboratories and pay Rs 1500/-. Already traumatized by the calamity, people won't wait to check water before using. Since nitrate is colourless and odourless it is difficult to detect without proper scientific techniques. The objective was to develop a low-cost nitrate sensing system that can non-destructively and continuously monitor the quality of water and it can be viewed real time on a mobile phone.

ii. Elimination of emerging contaminants in a multi-barrier water treatment system

Hongjiao Pang, University of Melbourne

The growing population and changing climate of the world are driving an increasing clean water demand as well as a decline in the availability of urban water of desired quality. In areas of water scarcity such as Australia and India, the problem is particularly acute. To meet the increasing demand within a finite freshwater availability, an alternative approach is to look at recycled wastewater as part of an adaptation strategy to secure a resilient future water supply. In this research, the interest is water recycle from contaminated water for potable supply in urban cities. However, the main issue is how to remove myriads of emerging contaminants. The objective of the research is to develop specific barriers protocols to understand their performance resilience to target contaminants and then classify chemicals and establish a multi-barrier system to eliminant the chemical risks.

iii. Assessment of water contamination by Lead ions by rapid optical nanoparticles-based bioreceptor techniques

Anna Berlina, A.N. Bach Institute of Biochemistry, Research Center of Biotechnology of the Russian Academy of Sciences

To control heavy metals in water, fast and efficient methods are needed. These possibilities are provided by analytical approaches based on the use of nanoparticles and specific receptor molecules. In this work, we used gold nanoparticles conjugated with aptamers for specific detection of target ions in the presence of other ones. The proposed aptamer-based assay combines homogeneous interaction and lateral flow separation of the formed labelled complexes. The analysis is based on the use of aptamers as bioreceptor molecules instead of widely implemented antibodies. The developed method is rapid (duration of analysis is 5 min), cost-effective and precise. Moreover, the described approach has a potential for its practical application as a tool for lead ions detection in aqueous media.

iv. Rainwater harvesting and primary treatment for non-potable use
Samia Richards, The James Hutton Institute

In a rural school in Berambadi, India, which experiences water shortage and rely heavily on groundwater, rainwater was harvested using two existing classroom roofs. The harvested rainwater was stored in a newly constructed underground water sump. Monitoring the stored rainwater indicated the presence of bacteria. To use the harvested rainwater safely for multiple purposes, treatment with sodium hypochlorite was conducted. Chlorine dosage from laboratory work was scaled up to treat the large volume of rainwater in the tank. The aim was to maintain chlorine residue at 0.2-0.5 mg/l for the harvested rainwater. The objectives of the study are to disinfect the harvested water with a low cost widely available material such as sodium hypochlorite and to bring water chlorine residue level to the recommended level by the WHO.

38. Urban Flood Risk

i. Reliability assessment of Bangalore storm water drain network considering LU/LC change and lake condition
Gouri Laxmeshwar, Indian Institute of Science

This paper presents an approach to estimate the reliability of a SWD network (system) in fuzzy framework. The approach includes: (i) estimation of reliability of conduits in SWD network in fuzzy framework, (ii) construction of a reliability block diagram (RBD) for the network, and (iii) use of the RBD and conduit reliability estimates to compute reliability of SWD network using Fuzzy Monte Carlo simulation-based procedure.

ii. Flood impact assessment in real time: A

case study of Chennai Bharath R, Aon Consulting Pvt. Ltd.

Occurrence of Floods usually have devastating impact on life and property. Effective flood management needs a continuous evaluation during/after an event. Such an evaluation would involve gathering information regarding the damages in real time. The current practice in monitoring real-time flood events includes use of remotely sensed flood extents to assess the flood affected areas. The study aims at improving real-time flood risk assessment for loss estimates and relief activities.

iii. Coastal flooding in Vietnam and effect of sea level rise along its deltas Naveen Ragu Ramalingam, Aon Consulting Pvt. Ltd.

Vietnam's long and highly populated coastline is prone to risks associated with typhoons and its accompanying storm surges. The coastal flood risk due storm surge is estimated with a stochastic approach utilizing a hydrodynamic model. Our objective is to estimate the coastal flood risk due to storm surge for Vietnam and its highly populated Deltas – Red River and Mekong. A stochastic typhoon catalogue is prepared using the historical track and storm parameters, the related storm surge of each event was simulated using a hydrodynamic model setup in Delft3d which solves the Shallow water Equations (SWE) risk. The analysis of risk related to storm surge hazard based on just considering a few historic events or worst-case scenarios helps provide an estimate of the possible magnitudes and provide references for planners and stakeholders.

iv. Probabilistic flood model for quantification of risk for insurance perspective Santosh Dronamraju, Aon Consulting Pvt. Ltd.

Losses due to the damages caused by natural catastrophes are largely uninsured, in developing as well as developed countries. Determining losses due to flooding can help to evaluate mitigation measures as well as fix insurance pricing in the event of a catastrophe. In general, catastrophe models consist of hazard, exposure, and vulnerability components. In the present study, a probabilistic approach to flood loss estimation is presented from an insurance perspective and applied on a river basin. The major objectives are (a) to present the need for a flood risk model focused on the user (a) to develop a probabilistic flood risk model for various watersheds in India,(b) assess the losses and mitigate the hazard in key areas (c) to cater the need for development of risk profile for marginalized sections of India.

v. Evaluation of the combined sewer system of Bangalore using SWMM Reshmi Devi, B.M.S. College of Engineering, Bengaluru

Bengaluru, (Latitude: 12.97 N and Longitude: 77.59 E) situated at an altitude of 900 m above mean sea level and receives a mean annual rainfall of 975 mm in about 60 rainy days (Bhandiwad, 2015). In this study the drainage network

of Bangalore city is modelled using SWMM (Version 5.1) and various conduits are analyzed for the flood carrying capacity. A part of Vrishabhavathi valley with a catchment area of 3150 ha and outlet near the Gali Anjaneya Swamy Temple, in Byatrayanapura Ward, is identified as the case study area.

39. Urban Water Resilience and Innovation

i. Creative, Ingenious and sustainable water strategies for urban water resilience Akash Sondhi, TERI School of Advanced Studies

This paper aims at appreciation of the advantages of the revival of creative water systems from the past in 21st century to increase the resilience of the urban ecosystems towards climate extremes. It also aims at providing a workable perspectives to the policy makers to and share new paradigm in legal norms towards sustainable urban water management.

ii. A water sensitive approach for cities in India Harry Virahasawmy, Alluvium Consulting Australia

Traditional water systems have given us critical benefits such as clean water, safe sanitation and effective drainage. However, we now recognise that adaptations are needed to urban water systems to address key social and environmental vulnerabilities such as degraded waterways, uncertain water supplies and growing community expectations. This paper draws on literature review and a range of practical experience in Australia and India to identify the benefits and goals of a "water sensitive city" and their relevance to cities in India.

iii. AquaGen - A sustainable water management system Ganesh Shankar, Alluvium Consulting Australia

Water is a vital ingredient for Home and Industry consumption. With many regions in the world facing water crisis and becoming water stressed, the importance of managing water wisely has come to the forefront of public consciousness. AquaGen is a sustainable Water Management Solution developed by FluxGen. AquaGen's architecture is based on the Industrial Internet of Things Technology (IIoT) and Machine Learning algorithms. This device analyses the data to communicate consumption patterns and offers insightful inputs to the facility manager to take corrective actions.

iv. Innovation capabilities in Water Governance for accelerating sustainability transitions

Chitresh Saraswat, Australian National University

Amidst the increasing call for innovation to support the transition towards water security, this study critically evaluates the hypothesis that advancing innovation capabilities accelerates sustainability transitions in the water sector. Also, it investigates which water governance modes are more equipped to develop innovation capabilities. The study found that water utilities operating under PPP and Employee cooperative may indeed have increased abilities to developing sustainability-related innovation and hence accelerate sustainability transitions in developing countries in comparison to the public water mode of governance.

40. Water Ethics: Practical Applications

i. Reshaping Rivers through Public Art
Ravi Agarwal, Toxics Link

Water sustainability needs consideration of rivers from an ecological perspective; for that a shift of ideas involving an interdisciplinary approach is required. Art can play an essential role in help achieving this. Through three public art projects it is demonstrated how aesthetic experiences emerged from critical artistic interventions contribute to create the idea of rivers as extended ideas of nature and public spaces. This investigation demonstrates that the dominant perceptions of rivers has been constructed by narrow approaches excluding important features and actors integral to river systems. It also suggests a more holistic and inclusive approach towards building river narratives which can contribute to sustainable practices.

ii. Creating a water positive community that champions long term water management solutions
Sathiyabama, JSW Group

With the rains becoming more erratic, green cover replaced by concrete jungles, disappearing natural/manmade water storage structures and lost indigenous knowledge, the people are facing drinking water scarcity. JSW addressed the problem first by addressing their immediate needs of drinking water, later came up with five-year plan for water management, then to align its developmental goals with SDG6. Owing to the complexity of the issue, JSW identified the root causes of the problem and worked on a comprehensive system to address the drinking water problem in long term.

iii. Nibi (water) Declaration: Anishinaabe water governance in the Treaty 3 area in Northwestern Ontario (Part I: Governance and Indigenous normative values)
Aimee Craft, University of

Ottawa

Beginning from the premise that water has a spirit, this project, the development of the Nibi Declaration probes Indigenous knowledge of sacred, cultural and spiritual relationships with water, with the purpose of better understanding the agency and personhood of water. The Declaration builds on land-based contextual knowledge of the Anishinaabe people of Treaty 3, an area which houses a significant amount of freshwater in Northwestern Ontario. Prioritizing the need to strengthen Treaty 3's Indigenous water governance, the purpose of this project is to support the development and ratification of a Nibi Declaration based on Indigenous normative values, principles and protocols. This will assist in clarifying roles and responsibilities that Anishinaabe, allies and external entities and decision-makers have and to support the exercise of those responsibilities.

Anishinaabe water governance in the Treaty 3 area in Northwestern Ontario (Part 2 – Governance and water management)

Lucas King, Grand Council Treaty #3
Treaty 3 is marked by rapid expansion in resource development such as mining, forestry and nuclear waste management. Indigenous knowledge speaks to water being alive and having a spirit, therefore the activities to protect it must respect this spirit and personhood. The Declaration will influence watershed management planning from a foundation of Indigenous values, bringing together the two paths of ceremony and management practices to protect Treaty 3 water for future generations. This creates a holistic approach, respecting all beings in creation, in water management unseen in current western practices.

iv. Nibi (water) Declaration:

41. Water Quantity and Quality Considerations in River Basin Planning and Management

i. India and Australia: A comparative assessment of water and river basin planning

David Winfield, Alluvium Consulting Australia

Across Asia, there is an increasing need to make a transition from water resources development to water resources management. India's experience of development and management in river basins draws on centuries of a strong cultural focus on water. Australia's recent experience in strategic water planning, allocation and assessment builds on over a century of policy interventions. Using a comparative analysis between India and Australia, this paper will discuss which elements of the Australian experience of water and river basin planning are likely to be most relevant in the Indian context. The paper will discuss policy reform options based on the Australian experience, including appropriate policy frameworks and related institutional and legal mechanisms to support effective

basin planning and governance in India.

ii. Modernization effects on sustainable water allocation - Yoda Ela, Sri Lanka

H. A. H. Jayasena, University of Peradeniya

Groundwater (19) and surface water (12) samples from 11 locations along the YEC were analysed to assess geochemistry and drinking and irrigation suitability. Electrical Conductivity, Residual Sodium Carbonate, Sodium Adsorption Ratio, Kelley's Ratio and magnesium hazard variations showed that water quality varied from good to doubtful. Cluster analysis, correlation matrix and the principal component analysis were performed. The overall analyses indicated that both surface and groundwater systems along the YEC were influenced by the rock-water interaction and anthropogenic inputs after the construction of the new JGC.

iii. Water infrastructure carrying capacity of Mahabaleshwar, a town in Western Ghats

Ankitha Shanbhogue, School of Planning and Architecture, New Delhi

Town in the Western Ghats with mere 13000 population and infrastructure designed to cater to resident population but annual tourist inflow of 15 lakhs,. Headwaters of Krishna and other smaller rivers – town lies within eco-sensitive region notified in 2001.Mahabaleshwar is a hill town in the Western Ghats, rich in biodiversity and a source of five major rivers including River Krishna. Removal of the ban in construction in 1975 caused a sudden growth of developmental activities and the region began to draw a large number of tourists for recreation and pilgrimage. To protect the ecology and biodiversity of the region, Mahabaleshwar Panchgani was declared as Eco-Sensitive Region in 2001.

iv. Qualitative assessment of water and sediment of Dhaleshwari River in Savar, Dhaka, Bangladesh

Khondoker Ahmed, Chemical Research Division, BCSIR Laboratories, Dhaka, Bangladesh Council of Scientific and Industrial Research (BCSIR)

Bangladesh is a south Asian developing country. The constant GDP growth of last few years makes to it a lower middle-income country. In the recent year's government is focusing on the industrial development over agricultural-based economy. However, the precaution for proper waste disposal and saving the aquatic ecosystem is not sufficient enough to protect the environment. The ecological environment of the Dhaleshwari river is vulnerable to pollution. Therefore, the authority should take strict environmental safety program for newly shifted tannery industries in Savar, Dhaka, Bangladesh.

v. Prediction of Jamuna River bank erosion condition using deep learning

Kazi Hasan, Bangladesh

University of Engineering and Technology

Traditionally riverbank erosion prediction task has been tackled using custom empirical equations for specific reaches, numerical modelling and linear regression-based techniques. With the emergence of deep learning and readily available satellite data, we leverage the power of artificial intelligence to develop integrated models that use historical satellite images along with traditional input factors of numerical modelling to predict future riverbank conditions for Jamuna River. End-to-end Neural Network based approach that borrows ideas from machine translation, is used to predict future Jamuna riverbank erosion states from historical satellite images. Integration of water level, discharge data into the network yields better accuracy than using satellite images as the only representation for riverbanks in predicting future bank lines.

vi. The role of vegetation in river response to a flood Joseph McMahon, Griffith University

The role of vegetation in the response of an Australian river to a large flood was assessed. The 62km study area was located in a water supply catchment which had experienced historical vegetation clearing, was downstream of a dam, and contained sand and gravel extraction sites. A combination of repeat LiDAR analyses, a generalized least squares model, collection of soil properties and historical photos were used. The GLS model indicated that a 1% increase in vegetation canopy cover significantly reduced riverbank erosion magnitude by between 2-3%. The aim of this study was to evaluate the role of riparian vegetation in river response to a large flood in the Mid Brisbane River catchment, Australia.

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ANNEXURE II: List of figures

Fig 15: Participants at the special session conference on Cryosphere and Water Security.

Fig 16: Dr. M Mani delivering lecture.

Fig 17: Dr. H S Negi delivering lecture.

Fig 18: Dr. R C Jain delivering lecture.

Fig 19: Poster session in progress.

Fig 20: Pannel discussion in progress.

Fig 21: Session on 'Future of Urban Waterbody Rejuvenation' in progress.

Fig 22: Discussions on 'Future of Urban Waterbody Rejuvenation' in progress.

Fig 23: One of the participant presenting in the session on 'Climate Change and Water Management at Water Future Conference'.

Fig 24: Random sessions in progress.

Fig 25: Attendees of the Ministers and MLAs meet held on 25 Sep 2019 at Hotel Sheraton Grand, Bengaluru.

Fig 26: High panel discussions in progress during the Ministers and MLAs meet.

Fig 27: One of the participants presenting during the Ministers and MLAs meet.

Fig 28: Prof. S. K. Satheesh talking during the Ministers and MLAs meet.

Fig 29: Mr. P.D. Rai addressing the attendees of the Ministers and MLAs meet.

Fig 30: Session on Assessing Sustainability in Water Space in progress.

Fig 31: Groundwater Assessment and Analytics session in progress.

Fig 32: Socio-cultural and Ecological Dimensions of Water Resources Management session in progress.

Fig 33: Groundwater Quality and Assessment I session in progress.

Fig 34: Leaving No One Behind: Digital Water, Big Data, Technology and Water Security session in progress.

Fig 35: Water and Climate Change Assessment I session in progress.

Fig 36: Data Issues and Needs Related to Monitoring Sustainability in Water Space I session in progress.

Fig 37: Urban Flood Risk and Adaptation session in progress.

Fig 38: Governance: Knowledge Management and Innovation session in progress.

Fig 39: Water-Energy-Food Nexus Governance session in progress.

Fig 40: Agriculture and Water session in progress.

Fig 41: River Basin Governance session in progress.

Fig 42: Water Security, Informal Water Use and Water Access session in progress.

Fig 43: An Integrated Global Vision for Water Security: Approaches and Methods session in progress.

Newspaper Coverage

Conference on water issues begins in city

STAFF REPORTER
BENGALURU

Hundreds of scientists and policy-makers participated in the three-day International Water Future Conference, which kicked off on Tuesday.

The conference, organised by the Divecha Centre For Climate Change, Indian Institute of Science, and Sustainable Water Future, a global research platform, aims to seek solutions for global water management. "The conference will address the current state of global water resource challenges, future pathways and different technological or institutional solutions that will accelerate the implementation of water-related sustainable development goals (SDGs)," said Anurag Kumar, director of IISc.

He voiced his hopes to consolidate the efforts of academics, water practitioners, policy-makers, scientists, civil society an[d] government officials to d[is]cuss the direction in wh[ich] the global community

IISc meet on climate change from today

BENGALURU, DHNS

The I[ndian Ins]titute of Sci[ence] ... its new a[r]... to add... to cli...

One immediate move by the IISc is a three-day conference on climate change, organised in collaboration with the Ministry of Earth Sciences, plus uni[versities] and institutes, which ... on Tuesday. ... [Ex]ecutive

MP to scientists: Avoid complex terms

TIMES NEWS NETWORK

Bengaluru: A conference in the city saw scientists defending the relevance of scientific procedures on Tuesday after a BJP MP remarked that complex technical terms were not being understood by the public.

Scientists retorted to the MP's remark saying though they try to simplify explanations, policy translation was a separate subject and they were not trained for it. "We do write special policy briefs with no technical terms for the benefit of policymakers. In fact, several international scientific documents have a separate summary for policymakers," a scientist said.

BJP MP Rajiv Pratap Rudy remarked at the open[ing] ceremony of the conference — Towards a sustainable water future — that scientists must offer simple solutions which can be comprehended by policymakers.

Rudy said scientists need to educate politici[ans with]out diffic[ult terminol]ogies...

BJP MP Rajiv Pratap Rudy said scientists need to educate politicians but without difficult terminologies and offer simple solutions which can be comprehended by policymakers

... to tourists' entry into a tiger reserve had been laid down in extremely complex terms. "It is a three-page formula with calculus," he said adding that science should be translated into simple words.

Responding to this, scientists at the conference said there's a need for community engagement for ground-based data collection as well as an attempt to translate scientific terms so that they're understood by the common man.

Veena Srinivasan, a programme leader at Ashoka Trust for Research in Ecology and the Environment (ATREE), a city-based research institution, said there's a need to invest in better data collection techniques and integrate the local with interdisciplinary science. "There's a

feeling that science has nothing to contribute to communities and when it comes to mitigating environmental issues, they will manage on their own," Veena said during a panel discussion on water security challenges.

'Policymakers must listen to scientists'

Alan Jenkins, deputy director of the UK-based Centre for Ecology and Hydrology, said though he agreed with Rudy's statement to simplify scientific language, he asked politicians to keep off science just like the latter should stay out of p... matters. "It is our job ... [under]stand the environ... [our] job to take ac[tion] ... re...

For greener world, netas must listen to scientists

EXPRESS NEWS SERVICE @ Bengaluru

"POLITICIANS have to listen to scientists. They have to understand how the environment will change," said Deputy Director of Centre for Ecology and Hydrology Alen Jenkins on Tuesday.

He was talking to mediapersons on the sidelines of the three-day conference — 'Water Future' — on the future of sustainable water, organised by the Divecha Centre for Climate Change.

Jenkins was responding to an earlier comment made by former minister of state for skill development and entrepreneurship Rajiv Pratap Rudy who cautioned the scientific community to cut the jargon.

While Rudy believed Indians were committed to the cause of global change, he said they were yet to be exposed to the gravity of the situation. To emphasise his point, he said, "In the entire session of the parliament, 266 members raised issues of drinking water and water scarcity issues. Every day, there was one issue brought up in common, and that was water."

Being a part of the national tiger conservation authority, Rudy said there were rules on how to allow tourists to go inside a tiger reserve. A three-page formula with calculus is in it for tourists to visit.

Venna Srinivasan, programme leader at water, land and society, ATREE, also said it was important for scientists to learn facts versus values and interests.

The conference had scientists, researchers and in a rare occasion had government representatives, who would take the science of climate change and the need for action to the masses.

'Nepal responsible for floods: Ex-minister'

Rajiv Pratap Rudy blamed deforestation caused by Nepal for floods in th[e] Indian st[ates] ... N... fe... nun... the c... areas... their ti... food req... as the tre... have retai[ned] water. Rudy raked up the ... of Bundelkha[nd] water canal. "It... water scarce are[a] and a 260-km canal was to be built. However, the dispute has prolonged for 15 years, as the project passes through a tiger reserve. Now, there is a dispute on getting water or saving the tiger," he said.

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At conference on science, science comes under attack

BJP's Rudy says 'science too difficult', should be simplified

BENGALURU, DHNS

At a science conference intended to find new solutions to climate change, the value of science itself became a topic of debate when MP described complicat

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to address climate change through sustainable water solutions, said scientific solutions to pressing problems were too overtly complex and beyond the gamut of understanding of laypersons.

"Scientists need to educate

(L-R) Former MP P D Rai, IISc Director Prof Anurag Kumar and BJP parliamentarian Rajiv Pratap Rudy at a conference at IISc on Tuesday. DH PHOTO/B K JANARDHAN

ness could only come he said.

His comments appeared to

ductive," he said.

Dr Alan Jenkins, deputy director of the centre for ecology and hydrology, said he did not share Rudy's point of view.

"Politicians have to listen to scientists — no matter what the complexity of their research is. It is our job to understand how the environment changes. It is the job of the political class to act on our findings and advice," Jenkins said, adding that politicians should stay out of the scientific process just as scientists should stay out of politics.

Another scientist that *DH* spoke to, said he interpreted Rudy's comment as a faux pas

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Soon, B'luru water data will be at your fingertips

TIMES NEWS NETWORK

Bengaluru: What's the quantity of groundwater residents of Whitefield are consuming? How much of Cauvery water is getting wasted in Shantinagar? How good is the quality of treated water coming out of Bangalore Water Supply and Sewerage Board's sewage treatment plants? All such information will soon be available at your finger

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A TIMES OF INDIA INITIATIVE

One of the main deliverables under the MoU is to develop a dynamic near-real-time Water Security Index (WSI) at the ward-level for Bengaluru. Key indicators of this index include water-use efficiency, resilience, relative water scarcity with special

Only 15mld of treated water sold

Sharachchandra Lele of Ashoka Trust for Research in Ecology and the Environment, Bengaluru (ATREE), who is part of Water Solutions Lab, there is a

Call it Beng Water

Researchers highlight problems of city lakes

They say permanence for lake management will entail regular monitoring of waterbodies

PRAGATHI R.

Permanence for lake management will entail regular monitoring, said researchers during a discussion on the problems plaguing the city's lakes at the 'Water Future Conference', here on Wednesday.

Researchers working on the city's lakes spoke about the problems specific to those lakes. Priyanka Jamwal, from Ashoka Trust for Research and Ecology and the Environment (ATREE), talked about the importance of managing dissolved oxygen levels in Jakkur lake, as part of her ongoing case study.

"There are a lot of issues in Jakkur lake, there are several reported instances of fish kill, algal bloom, bird deaths. People tried to investigate the reasons for the bird deaths, but it was inconclusive. This brings to the question that why aren't STP's and other interventions not working," she said. Terming it a critical water quality parameter, she added: "Dissolved oxygen le

A researcher talked about importance of managing dissolved oxygen levels in Jakkur Lake. - PTI PHOTO

vels should not be less than 4 milligrams per litre if we want our lakes to be used for the propagation of fisheries. They also indicate if the lake is receiving a poor quality of inflows."

Inflows in an urban setting can be categorised into treated effluent, untreated wastewater, and storm water, consisting of clay, silt and sand. "Dissolved oxygen levels also contribute to the self cleansing capacity of the wa

ter body and therefore is of high importance to uphold the health of the lake. When this study was conducted, Jakkur lake receives inflows of 10 million litres per day," she said.

Lake conservation

On the topic of lake conservation, Amrita Sen from Indian Institute of Technology (IIT), Kharagpur, was of the opinion that habits of lake conservation can be in

culcated in citizens. "Environmental placemaking is a social process where attachments and physical experiences are discursively integrated to create a shared sense of place identity. So place is not just a geographical location, but also a social one."

Her case focused on the rehabilitation of Kaikondarahalli and Kaneenahalli lakes. "After the restoration of the lakes, it was found that it has

Models for flood mitigation

STAFF REPORTER

At a session on 'lake quality assessment and case studies', scientists and researchers pitched scientific models for mitigation of floods. Gowri Shankar K., from M.S. Ramaiah Institute of Technology, proposed a design of road crossings for preventing floods.

"An adjustable bridge (in the case of roads and highways built over rivers and lakes) can be installed with a sensor to detect the increasing water levels and accordingly elevate themselves out of reach," he proposed.

become a place where people come together to spend time." She attributed this to the socio-cultural practices coupled with a sense of belongingness that transformed these natural spaces into shared social spaces and sustainable urban convents.

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