

# HYDRO 2020 INTERNATIONAL CONFERENCE

(Hydraulics, Water Resources & Coastal Engineering)

Silver Jubilee Year

26-28 March 2021

Souvenir



Diamond Jubilee Year  
NIT ROURKELA



1961 - 2021, 60 Glorious Years of Service

Rourkela Steel Plant



Mandira Dam



Organized by  
Department of Civil Engineering,  
National Institute of Technology Rourkela  
Odisha, India

In Association with  
Indian Society for Hydraulics, Pune





## ***Significant Milestones of NIT Rourkela***

- 2021** Diamond Jubilee Celebrations
- 2020** Inauguration of Golden Jubilee Building, The tallest structure and pride of Rourkela City
- 2010** Celebrated Golden Jubilee
- 2007** Declared Institute of National Importance via Act of Parliament
- 2002** Renamed National Institute of Technology (NIT) Rourkela
- 1994** Achieved Academic Autonomy
- 1986** Celebrated Silver Jubilee
- 1965** Inclusion of Science departments into the REC system
- 1961** Founded as Regional Engineering College (REC) Rourkela

15th August



# XXV HYDRO 2020 INTERNATIONAL CONFERENCE

(Hydraulics, Water Resources & Coastal Engineering)

March, 26-28, 2021

Silver Jubilee Year



## Editors

**Prof. Kanhu Charan Patra**  
**Prof. Kishanjit Kumar Khatua**  
**Dr. (Mrs) Sanat Nalini Sahoo**  
**Dr. Ratnakar Swain**  
**Dr. Anurag Sharma**



***Organized by***  
**Department of Civil Engineering,**  
**National Institute of Technology Rourkela**  
**Odisha, India**

***In Association with***  
**Indian Society for Hydraulics, Pune**



# Preface

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HYDRO 2020 International Conference on Hydraulics, Water Resources, Coastal & Environmental Engineering, being organized at NIT Rourkela under the aegis of the Indian Society for Hydraulics, is an annual get together of Scientists, Researchers, Academicians, Practicing Engineers, and Consultants all over the world related to Water Engineering and has evolved over the years and earned an international reputation and recognition in this topic. The conference mainly focuses on state-of-the-art technologies and applied research in the field of Hydraulics, Water Resources, Coastal & Environmental Engineering. The present 25th (silver jubilee) episode of the conference is being organized at the National Institute of Technology Rourkela.

NIT Rourkela was established on 15 August 1961 and its foundation stone was laid by the first Prime Minister of India, Pt. Jawaharlal Nehru. NIT Rourkela is a premier institute of national importance funded by the Government of India is committed to quality technical education in the country. It is a residential campus offering accommodation to faculty, staff, and students. The campus of the Institute consisting of the Academic area, halls of residence area, and staff colony area is situated at the eastern end of Rourkela steel city. The green and beautiful campus has all the amenities for developing personal, social, and academic skills of the student, faculty, and staff community. HYDRO 2020 International Conference on Hydraulics, Water Resources, and Coastal Engineering is being organized at NIT Rourkela in its silver jubilee year coinciding with the diamond jubilee year of NIT Rourkela through online mode on behalf of the Department of Civil Engineering, NIT Rourkela, and Indian Society for Hydraulics. It is our proud privilege to welcome you all to this renowned International Conference. Despite the current pandemic situations throughout the globe, more than five hundred abstracts of the papers have been received and after the review, about 290 full papers have been finally accepted. Ten senior scientists of high expertise from abroad and twenty-four senior scientists from reputed Institutes/ Universities of our country will be delivering their expertise and knowledge in the emerging field of Water Resources Engineering. Around 24 senior scientists will also be chairing the sessions covering all the themes of the Conference.

The HYDRO 2020 proceedings volume contains peer-reviewed technical papers under 18 themes and covers a wide spectrum of research studies, experimental outputs, case studies, review papers, and papers related to the management of Water Resources and Coastal Engineering. We are indeed happy to bring on this occasion, souvenir containing abstracts of the Keynotes and Invited talks along with the quality technical papers selected for the presentation. Further, proceedings of the conference are also released in electronic forms that are arranged theme-wise.

We take this opportunity to express our sincere thanks and gratitude to all members of the International and National Advisory Committee members, the Technical Committee as well as the Organizing Committee members along with student volunteers, authors, and reviewers.

We appreciate the untiring efforts of conference organizers, generous support from sponsors, continuous guidance, support, and encouragement from all academic and research institutions. We strongly hope that the deliberations and discussions at the HYDRO 2020 International Conference will promote useful and fruitful interactions among participants and thus help professionals working in the field of Hydraulics, Water Resources, and Coastal Engineering. Looking forward to fruitful deliberations in the HYDRO - 2020 conference in virtual mode.

-Editors

**Prof. Ganeshi Lal**  
Governor, Odisha



Raj Bhawan  
Bhubaneswar – 751 008

## **MESSAGE**

I am happy to know that the Water Resources Division of the Department of Civil Engineering, National Institute of Technology, Rourkela is organizing the HYDRO-2020 International Conference on Hydraulics, Water Resources and Coastal Engineering on 26-28 March 2021 in online mode and a souvenir is being published on the occasion.

New issues need new solutions. We need to keep track of new technologies and adapt for our benefit. Tech options are there, but it requires prudence to use that based on suitability to the ecosystem. I hope the conference will provide a platform for the exchange of ideas on various contemporary issues and will be a great learning experience for all stakeholders.

I wish the conference and publication all success.

A handwritten signature in black ink, appearing to read 'Ganeshi Lal'.

Ganeshi Lal

**Ramesh Pokhriyal Nishank**  
Minister of Education  
Government of India



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Shastri Bhawan, New Delhi  
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## **MESSAGE**

I am pleased to learn that the Department of Civil Engineering, National Institute of Technology, Rourkela (Odisha) is organizing the 25th International Conference on "Hydraulics, Water Resources and Coastal Engineering (HYDRO-2020)" under the aegis of The Indian Society for Hydraulics (ISH), Pune during 26-28 March 2021.

Not only for sustaining life, but water is also quite essential for the agriculture industry and trade & commerce. For all forms of life and energy generation, be it animate world or hydroelectric projects, thermal power plants, or nuclear power plants, water is a sine qua non. So, it is our paramount responsibility to conserve water resources – the true elixir of life. It is possible only by changing our outlook towards this wonderful natural resource that sustains all forms of life.

I am sure that the assembly of a galaxy of eminent professionals in the field of water resources, meeting virtually, will have very extensive and mutually enriching deliberations and tangible outcomes will emerge from the Conference. I congratulate the organizers and the participants and wish the HYDRO-2020 a grand success.

Ramesh Pokhriyal 'Nishank'

**Dharmendra Pradhan**  
Minister of Petroleum & Natural Gas  
and Steel  
Government of India



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## **MESSAGE**

I am pleased to learn that the Water Resources Division of the Department of Civil Engineering, National Institute of Technology, Rourkela, is organizing the 25th edition of HYDRO-2020 International Conference of Hydraulics, Water Resources, and Coastal Engineering under the aegis of Indian Society for Hydraulics (ISH), Pune on 26th-28th March 2021.

NIT ROURKELA, which completes 60 years on 15th August 2021, has been one of the leading engineering institutes in the country and the pride of Odisha for generations. Located in the heart of the State's industrial and mineral belt, NIT Rourkela has not only produced the brightest academicians, industrialists, and scientists but also immensely contributed to the economic development and industrial growth of Odisha especially Western Odisha.

Water resources have been identified as a key driver of India's growth and development by Hon'ble Prime minister, Shri Narendra Modi. While the Jal Shakti Mission aims to deliver potable piped drinking water to every Indian household, Blue Revolution strives to unlock the potential of coast-led development in States like Odisha.

I am hopeful that HYDRO-2020's panelists from reputed national and international organizations, faculty members, students, and visitors will discuss novel applications of engineering in providing solutions for making India Atmanirbhar with respect to the water resources.

I wish my very best to the NIT-HYDRO 2020-International Conference.

  
(Dharmendra Pradhan)

**Pankaj Kumar**  
Secretary  
Ministry of Jal Shakti  
Department of Water Resources,  
River Development &  
Ganga Rejuvenation  
Government of India



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## **MESSAGE**

I am very pleased to know that a three-day HYDRO 2020 International Conference is being organized by the Department of Civil Engineering, National Institute of Technology, Rourkela from 26th to 28th of March, 2021.

I commend the National Institute of Technology, Rourkela for organizing the 25th Edition of the International Conference under the aegis of the Indian Society for Hydraulics (ISH), Pune. I am confident that the conference will contribute significantly to the efforts for increasing availability of the water resources in a sustainable manner. It would provide a platform for learners as well as professionals to interact in the fields of hydrology, hydraulics, and ocean engineering.

I convey my greetings and best wishes to the organizers and participants of HYDRO 2020 - International Conference.

  
( PANKAJ KUMAR )

**Smt Anu Garg, IAS**  
Principal Secretary to Government



Department of Water Resources,  
Government of Odisha

## **MESSAGE**

I am extremely happy to learn that the Water Resources Division of Department of Civil Engineering, National Institute of Technology, Rourkela, is organizing the HYDRO-2020, an International Conference on Hydraulics, Water Resources, and Coastal Engineering under the aegis of Indian Society for Hydraulics (ISH), Pune during 26th – 28th March 2021 (in online mode) to witness silver jubilee of HYDRO and Diamond jubilee of NIT Rourkela.

It is my pleasure to know that reputed Scientists, Engineers, Academicians, Researchers, Professionals, and Students shall attend this conference. This conference shall share an insight into the recent developments, research, and cutting-edge technology, which gains immense interest in the field of Hydraulics, Water Resources, and Coastal Engineering particularly in the changing scenario due to climate change.

I am glad to know that on this occasion a souvenir is also being published and wish the student volunteers, HYDRO-2020 international, NIT Rourkela for the grand success of the silver jubilee of HYDRO and Diamond jubilee of NIT Rourkela.

Anu Garg

**Er. Jyotirmaya Rath**  
Engineer-in-Chief, Water Resources



Office of the Engineer-in-Chief  
Water Resources, Odisha  
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## **MESSAGE**

It is a great pleasure for me to know that the Department of Civil Engineering, National Institute of Technology, Rourkela have shown their keen interests in successfully organizing the Silver Jubilee edition of the reputed HYDRO-2020-International Conference (Hydraulics, Water Resources, and Coastal Engineering) on 26-28 March 2021 on several topics related to water and coastal resources and its systematic management.

Water, being the most valuable resource in the environment, shall be well managed and to know how to develop such is very essential. The organization of such a valuable event will gather the ideas of various experts on hydrology, hydraulics and coastal engineering, all over India and abroad. I hope all the talks, deliberations and thought processes will be well important for the development of the nation towards being resourceful and self-sufficient in water.

I heartily wish HYDRO-2020-International Conference to be at its grand success.

  
(Er. Jyotirmaya Rath) 22/3/2021

**Prof. Animesh Biswas**  
Director



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## **MESSAGE**

It is my deepest pleasure to address my gratitude to the Department of Civil Engineering, National Institute of Technology, Rourkela for organizing the silver jubilee of the prestigious HYDRO 2020 – International Conference where leaders and innovators are convoked together to share, inspire, and network in the field of hydraulics, water resources, and coastal engineering, all under the aegis of Indian Society for Hydraulics (ISH), Pune.

Water is the most vital resource amongst all others. An International Conference aiming at its development and management is certainly a great stage for discussions and deliberations regarding the same. The HYDRO 2020 – International Conference provides the chance for thinkers and professionals from India and abroad to provide their ideas for booming the developments of water and coastal resources.

I wish the organizers of HYDRO 2020 – International Conference my best wishes.

A handwritten signature in blue ink, appearing to read "Animesh Biswas". The signature is written in a cursive style and is underlined with a single horizontal line.

Prof. Animesh Biswas

**Prof. M. C. Deo**  
President, Indian Society for  
Hydraulics & Emeritus Fellow,  
I. I. T. Bombay



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## **MESSAGE**

On behalf of the Indian Society for Hydraulics and on personal behalf I extend very warm greetings to the organizers of Hydro 2020 – International Conference, for producing this Souvenir to mark the Silver Jubilee of the Hydro conferences. I compliment the Faculty and students of the Department of Civil Engineering, National Institute of Technology (NIT), Rourkela for taking initiative and organizing this prestigious Hydro conference. I am happy to mention that NIT Rourkela is well known for its excellent research contributions in the area of experimental as well as numerical studies in hydraulics and water resources.

Over a period of the last 25 years, the Hydro conferences have become a well-known and coveted platform for academicians, scientists, and professionals to showcase their novel and innovative research as well as field-oriented works in hydraulics, water resources, environmental and coastal engineering. An opportunity to listen to a number of invited talks and presentations by reputed scientists and engineers from the country as well as from abroad has been an attractive feature of this gathering. The rising popularity of the conference series held annually in different parts of India can be seen in the increasing number of research papers and delegates along with the number of sponsoring agencies, year by year.

I wish every success to the conference and hope that all participants will get truly benefitted from the conference proceedings.



M. C. Deo

**Dr. Eldho T.I.**

Vice-President, Indian Society for  
Hydraulics & Professor and Head,  
Dept. of Civil Engineering, IIT Bombay



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Indian Institute of Technology Bombay  
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## **MESSAGE**

I am very delighted to know that the Department of Civil Engineering, National Institute of Technology, Rourkela is organizing the 25th edition of HYDRO 2020 – International Conference under the aegis of Indian Society for Hydraulics (ISH), Pune. A souvenir of the silver jubilee is being produced so as to mark this renowned occasion of the International Conference.

The HYDRO 2020 – International Conference is a platform where leaders and innovators meet to share, inspire, and network in the field of hydraulics, water resources, and coastal engineering. It was very pleasing for me to know about some of the most well-known and influential voices in the field being hosted in the conference and a workout of such will be good enough for the society to be self-sufficient in any kinds of water resources maintaining the quality.

I hereby bid all my good wishes for the HYDRO 2020 – International Conference to achieve its grand success.

Prof. Eldho T.I.

**Dr. L.R. Ranganath**  
Secretary, ISH



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## **MESSAGE**

At the Outset, it gives me immense pleasure that the Department of Civil Engineering, National Institute of Technology, Rourkela under the aegis of The Indian Society for Hydraulics (ISH) is organizing an International Conference “HYDRO 2020 International” on Hydraulics, Water Resources, and Coastal Engineering during 26 -28 March 2021 on virtual mode due to COVID 19 at the prestigious campus of NIT which is an internationally acclaimed institution of higher learning.

Hydraulics is the most vital discipline of Engineering, serving mankind for centuries. I am happy to know that a very large number of good papers have been received for the Conference. I hope that the deliberations in the conference would go a long way in exchange for technical know-how & dissemination of knowledge and render an excellent platform for the newcomers in the field.

I would like to take this opportunity to affirm that The Indian Society for Hydraulics (ISH) set up in 1992 as a technical, non-profit national organization, encourages the Engineers and Scientists for the Research and Development in Hydraulics by organizing Conferences, publishing Research journal and by recognizing them through various awards. I appeal to all the Researchers and Engineers working in Hydraulics and allied fields to join the Society for the betterment of hydraulics and mankind.

I convey my best wishes to the organizers of the conference & look forward to its grand success which is being conducted online for the first time.



Dr.L.R. Ranganath

**Prof. K C Patra**  
Professor HAG, CED,  
Chairman, HYDRO – 2020



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## **MESSAGE**

It is indeed a matter of great pleasure and pride for the Department of Civil Engineering of NIT Rourkela in general and to me in particular, to organize the prestigious HYDRO-2020 International Conference under the aegis of the Indian Society for Hydraulics (ISH) Pune, during 26th - 28th March 2021 covering the topics on Hydraulics, Water Resources, and Coastal Engineering. This being the silver jubilee year of the said renowned conference coinciding with the Diamond Jubilee year of NIT Rourkela, a galaxy of Professors and Scientists from various reputed national and international organizations are expected to participate and deliberate on various contemporary issues related to the topics.

The subject of civil engineering is as old as human civilization. Almost every day, new technologies are added to its knowledge. With the advent of electronic gadgets, the standard of living has undergone a sea change that finally stresses on water demand.

I expect that the deliberations in the HYDRO-2020 international conference covering more than 300 research papers on the areas of water resources, hydraulics, and coastal engineering shall add great value to the researchers, academicians, consulting, and practicing engineers across the globe.

I wish the conference great success.

A handwritten signature in blue ink, appearing to read "K. C. Patra".

K. C. Patra

**Prof. Pradip Kumar Das**  
Registrar, NIT Rourkela



Registrar,  
National Institute of Technology  
Rourkela, Odisha -769008  
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## **MESSAGE**

I am very delighted to know that the Department of Civil Engineering, National Institute of Technology, Rourkela is organizing the 25th edition of HYDRO 2020 – International Conference under the aegis of the Indian Society for Hydraulics (ISH), Pune.

The First HYDRO conference was organized at IIT Kanpur in the year 1996 under the guidance of Founder President of ISH Prof Garde, University of Roorkee, when I was a Ph.D. scholar there. Now that platform of HYDRO has grown to a gigantic shape and I wish it will grow further and embrace some more interdisciplinary areas for its inorganic growth.

It is a fact, wherever there is water there is the growth of civilization. This precious God gift resource needs proper planning and management. I hope HYDRO is the right platform to put forth new ideas, technologies, and lateral thinking in the broad areas of Hydraulics in general and on its sub-domains in particulars. I wish the scientific review papers on different themes to be presented in the conference shall help the policy planners of our country and the world to think for effective use of both surface and groundwater. Further, I expect the participants who are from academics will have a brainstorming session on the dwindling situation on experimental research, instead of fully depending on simulation which sometimes is handicapped for the validation of its result.

Through this message, I like to recollect some of my teachers like Prof Ramaseshan, Prof K Subramanyam, Prof Surya Rao, Prof Bithin Dutta, Prof. BS Murthy, and Prof T. Gangadhariah who have taught me Hydraulics and Water Resources Engineering. We should not forget to salute the pioneers who have spent their lives shaping this subject to the present level.

I hereby bid all my good wishes for HYDRO 2020 – International Conference to achieve its grand success.



Prof. P K Das

**Prof. Rithwik Sarkar**  
Dean – SRICEE &  
Professor, Dept. of Ceramic Eng



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## **MESSAGE**

It is a pleasure for me to know that the Department of Civil Engineering, National Institute of Technology Rourkela organizing the Silver Jubilee year of the renowned and popular HYDRO International Conference “HYDRO 2020” during March 26-28, 2021. The conference will mainly focus on various aspects of the Water Resources, Hydrology, Coastal Engineering, and Environment in the changing scenario and discuss the viable solutions to the challenges being faced.

Water, being the most valuable resource in the environment, must be systematically and judiciously used and managed and the understanding to develop such concepts are very essential in the present time. The organization of such a valuable event will gather and generate concepts and ideas from various experts on Hydrology, Hydraulics, and Coastal Engineering across the globe. The conference will enhance the information exchange of theoretical research and practical advancements at national and international levels in all the concerned fields. The same will encourage and promote professional interactions among students, scholars, researchers, educators, professionals from Academics, Institutes, and Industries to share the latest findings in their respective fields towards sustainable developments. I hope all the expert talks, deliberations, and thought processes will be of great importance for the development of the nation towards a resourceful self-reliant India.

I heartily wish the HYDRO 2020-International Conference a grand success.

Rithwik Sarkar

**Prof. C. R. Patra**  
HOD, Dept. of Civil Engineering &  
Coordinator, TEQIP – III  
NIT Rourkela



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## **MESSAGE**

It is a pleasure for me that our Department of Civil Engineering, National Institute of Technology Rourkela is organizing the Silver Jubilee edition of the reputed HYDRO 2020 - International Conference (Hydraulics, Water Resources, and Coastal Engineering) from 26th to 28th March 2021 on several topics related to water and coastal resources and its systematic management.

Water, being the most valuable resource in the environment, should be well managed. Such a valuable conference will gather the ideas of various experts on hydrology, hydraulics, and coastal engineering, all over India and abroad. All the talks, deliberations, and thought processes will be well important for the development of the nation towards being resourceful and self-sufficient in water.

I heartily wish HYDRO 2020 – International Conference to be at its grand success.

C. R. Patra

**Prof. Kishanjit Kumar Khatua**  
Organizing Secretary, HYDRO 2020



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## **MESSAGE**

It gives me immense pleasure to share with you that our Civil Engineering Department, NIT Rourkela has started in the year 1961 and completed 60 years of its glorious contribution to the Institute by 2021. To mark the occasion of the diamond jubilee year of our Institute, the 25th edition of the prestigious HYDRO International conference in association with Indian Society for Hydraulics Pune during 26-28 March 2021 will make it more memorable.

This, being the silver jubilee year of the said renowned conference, a galaxy of top Professors and Scientists from a number of reputed national and international organizations are participating to deliberate on various contemporary issues related to water resources, hydrology, river hydraulics, coastal engineering, and other allied areas. The main aim of the conference is to bring all the leading academicians, scientists, researchers, professionals, field engineers, and consultants worldwide working in the field of hydraulics, irrigation, environment, and water sector to one platform to interact and participate in the deliberations.

The uniqueness of the event will be the presentations of around 34 keynotes & invited talks from the international and national level with high expertise on various issues of Water science. The focus is to exchange knowledge on various aspects of current water resources and environmental problems in the Globe and in the Indian context. The essence and conclusions of the deliberations will be communicated to the concerned authorities for implementation.

I would like to thank our valuable authors for contributing their quality research and fieldwork through this event. Also sincere thanks to the following International and National experts for agreeing to deliver expert talks.

The topic of invited/keynote talks are listed below:

International experts (Invited speakers):

1. Prof. Sameh Kantoush, Disaster Prevention Research Institute (DPRI), Kyoto University, Japan.  
Title: Integrated Reservoir Sediment Management at the River Basin for Sustainable Water Resources Management.
2. Dr. Sebastien Proust, INRAE, Lyon, France  
Title: Large-scale structures in transversally sheared open channel flows.
3. Prof. Hanif Chaudhry, USC, USA  
Title: How Reliable are the Results of Transient-Flow Models?
4. Prof. Chittaranjan Ray, University of Nebraska-Lincoln, USA  
Title: How best to manage Odisha's water resources for economic growth and future sustainability?
5. Prof. Evan Davis, University of Alberta, Canada  
Title: A Systems Approach to Water Resources Planning and Management
6. Prof. Xianon Tang, Xi'an Jiaotong-Liverpool University, China  
Title: Analytical modeling for predicting the flow velocity in vegetated channels
7. Prof. Nigel Wright, Deputy Vice-Chancellor for Research and Enterprise at Nottingham Trent University, UK  
Title: A novel means for identifying flood sources in urban areas to support the implementation of sustainable urban flood resilience.
8. Prof. P.K. Behera, Professor Chair, University of District of Columbia, Washington DC, USA  
Title: Engineering of Urban Water Systems for 21st Century and Beyond for India – Challenges and Opportunities
9. Prof. Ashok Mishra, Clemson University, USA  
Title: Hydroclimate extremes: Compound drought and heatwaves.
10. Prof. Debabrata Sahoo, Sustainable Water Resources, Clemson University, USA  
Title: Digital water- The technological wave to manage, analyze, and inform hydrologic assets.

Keynote Speakers from various premier institutions across the Nation:

1. Prof. M C Deo, IIT Bombay  
Title: Future shoreline erosion and sea-level rise at some of the Indian coastal locations.
2. Dr. R. N. Sankhua, Chief Engineer (South), NWDA, Hyderabad  
Title: Hydroinformatics and hydro-diplomacy in shaping sapiency for troubled waters of Mahanadi
3. Prof. T I Eldho, IIT Bombay  
Title: Climate Change and Land Use Impact Assessment on Hydrology- A Regional Scale Approach
4. Prof. C. S. P. Ojha, IIT Roorkee  
Title: Evolution of Rainfall-Runoff Models

5. Prof. D Nagesh Kumar, IISc, Bangalore  
Title: Remote Sensing & GIS for Flood Inundation Mapping.
6. Prof. S Dutta, IIT Guwahati  
Title: Complexities in Urban Hydrological Modelling: Research Progress and Future Directions.
7. Prof. Dwarakish G. S., NIT Surathkal  
Title: Geoinformatics in Coastal and Ocean Engineering
8. Prof. P. L. Patel, SVNIT, Surat  
Title: Impact of climate variability on Water Security of Tapi basin
9. Prof. C. Madhusudana Rao, NIT Jamshedpur  
Title: Application of simplified routing methods for hydrometric data-based real-time flood forecasting
10. Prof. Pranab Mohapatra, IIT Gandhinagar  
Title: Detection of partial blockage in the piping system
11. Prof V R Desai, IIT Kharagpur  
Title: Sustainable water management through promotion of voluntary afforestation.
12. Dr.L.R.Ranganath, Scientist E, CWPRS  
Title: Evolution of a navigational channel in Tapi estuary through model studies.
13. Prof. P.C. Swain, VSSUT, Burla  
Title: Flood management in tropical countries with special reference to medium and small catchments.
14. Prof. Sunil Sarangi, Ex-Professor, IIT Kharagpur  
Title: An Overview of Industrial Water Supply Systems
15. Er. Jyotirmaya Rath, EIC, WR, Odisha.  
Title: Shoreline protection for Odisha Coast with a case study on Geo-tube Embankment at Pentha in Kendrapara District.
16. Prof. K. V. Jayakumar, NIT Warangal  
Title: Modelling of environmental flow requirements using hydrological and habitation models
17. Prof. A.K.Gosain, IIT Delhi  
Title: Recipe for Achieving Water Security & Sustainable Development in India.
18. Prof. R Maity, IIT Kharagpur  
Title: Temporal Networks-Based Approach for Nonstationary Hydroclimatic Modelling.
19. Prof. Manas R. Behera, IIT Mumbai  
Title: Coastal Vulnerability in a changing climate.
20. Prof. Subba Rao, NIT Surathkal  
Title: Analysis of coastal erosion problems in the vicinity of Netravathi-Gurpur river estuary, west coast of India – a modeling approach.
21. Prof. V. Jothiprakash, IIT Bombay  
Title: Sedimentation rate and behavior analysis using chaos theory
22. Prof. D. P. Acharya, NIT Rourkela  
Title: Intelligent lot for Water Resource Management
23. Er. Ashutosh Dash, CE cum Additional Secretary Dept. of Water Resources, GoO.  
Title: Uttarakhand flood – 2021: Reasons and lessons to learn

24. Prof. Rajiv Bhattacharya, IIT Guwahati

Title: Status and Management of Groundwater in India

I am sure that the deliberations by the experts and presentations by the valuable authors during the HYDRO-2020 International (online) will result in appropriate recommendations. We look forward to meet all the dignitaries and participants of the International conference through the virtual mode.

We hope that discussions, presentations, and outcomes during this conference will provide positive results towards effective Water Resources management. A souvenir of the HYDRO 2020 conference (silver jubilee) is being produced to mark this renowned occasion.

I wish the HYDRO 2020 International Conference a grand success.

Thank You,



Prof. Kishanjit Kumar Khatua

### ***Chief Patron***

**Prof. A. Biswas**

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## PROGRAMME SCHEDULE SUMMARY

<b>DAY-1</b>	
<b>26<sup>th</sup> March, 2021 (Friday)</b>	
<b>09:00 am to 11:10 am</b>	<b>INAUGURATION OF SILVER JUBLIEE OF HYDRO 2020 AND ANNUAL ISH AWARDS CEREMONY</b>
<b>11:10 am to 11:40 am</b>	<b>S. N. Gupta Memorial Lecture</b>
<b>11:40 am to 11:45 am</b>	<b>BREAK</b>
<b>11:45 am to 12:25 pm</b>	<b>Invited Speaker -1</b> <b>Prof. Sameh Kantoush, Disaster Prevention Research Institute (DPRI), Kyoto University, Japan</b>
<b>12.25 pm to 12.35 pm</b>	<b>Sponsor Presentation</b>
<b>12:35 pm to 12:45 pm</b>	<b>BREAK</b>
<b>12:45 pm to 1:25 pm</b>	<b>Invited Speaker -2</b> <b>Dr. Sebastien Proust, INRAE, Lyon, France</b>
<b>1:25 pm to 2:10 pm</b>	<b>BREAK</b>
<b>Six Parallel Sessions</b> <b>2:10 pm to 5:20 pm</b>	<b>Server 1: (Theme: Coastal and Ocean Engineering)</b> <b>Keynote 1: Prof. M C Deo, IIT Bombay</b> <b>Parallel Session-1: 10 papers</b>
	<b>Server 2: (Theme : River and Coastal Engineering)</b> <b>Keynote 2: Dr. R. N. Sankhua, Chief Engineer (South), NWDA, Hyderabad</b> <b>Parallel Session-2: 10 papers</b>
	<b>Server 3: (Theme : Effect/Impact of Climate Change on Water Resources)</b> <b>Keynote 3: Prof. T I Eldho, IIT Bombay</b> <b>Parallel Session-3: 10 papers</b>
	<b>Server 4: (Theme : Hydraulic &amp; Hydrologic Modelling)</b> <b>Keynote 4: Prof. C. S. P. Ojha, IIT Roorkee</b> <b>Parallel Session-4: 10 papers</b>
	<b>Server 5: (Theme : RS/GIS Application for Water Resources Management)</b> <b>Keynote 5: Prof. D Nagesh Kumar, IISc, Bangalore</b> <b>Parallel Session-5: 10 papers</b>

	<p align="center"><b>Server 6: (Theme : River Hydraulics)</b></p> <p><b>Keynote 6:</b> Prof. S Dutta, IIT Guwahati</p> <p><b>Parallel Session-6: 10 papers</b></p>
<b>5:20 pm to 5:30 pm</b>	<b>BREAK</b>
<b>5:30 pm to 6:10 pm</b>	<p><b>Invited Speaker-3</b></p> <p><b>Prof. Hanif Chaudhry, USC, USA</b></p>
<b>6:10 pm to 6:50 pm</b>	<p><b>Invited Speaker-4</b></p> <p><b>Prof. Chittaranjan Ray, University of Nebraska-Lincoln, USA</b></p>
<b>6:50 pm to 7:00 pm</b>	<b>BREAK</b>
<b>7:00 pm - 8.00 pm</b>	<b>General Body Meeting of ISH (Will be conducted by ISH)</b>

**NB: All times mentioned are in Indian Standard Time (IST)**

<b>DAY-2</b> <b>27<sup>th</sup> March, 2021 (Saturday)</b>	
<b>08:30 am to 9:10 am</b>	<b>Invited Speaker -5</b> Prof. Evan Davis, University of Alberta, Canada
<b>09:10 am to 09:20 am</b>	<b>BREAK</b>
<b>Six Parallel Sessions</b> <b>09:20 am to 12:30 pm</b>	<b>Server 1: (Theme : Coastal and Ocean Engineering)</b> <b>Keynote 7:</b> Prof. Dwarakish G. S., NIT Surathkal <b>Parallel Session-7: 10 papers</b>
	<b>Server 2: (Theme : Hydraulic &amp; Hydrologic Modelling)</b> <b>Keynote 8:</b> Prof. P. L. Patel, SVNIT, Surat <b>Parallel Session-8: 10 papers</b>
	<b>Server 3: (Theme : Flood Forecasting and Management)</b> <b>Keynote 9:</b> Prof. C. Madhusudana Rao, NIT Jamshedpur <b>Parallel Session-9: 10 papers</b>
	<b>Server 4: (Theme : Urban Water Management)</b> <b>Keynote 10:</b> Prof. Pranab Mohapatra, IIT Gandhinagar <b>Parallel Session-10: 10 papers</b>
	<b>Server 5: (Theme : Watershed Management)</b> <b>Keynote 11:</b> Prof V R Desai, IIT Kharagpur <b>Parallel Session-11: 10 papers</b>
	<b>Server 6: (Theme : Hydraulic Structures and Hydropower Engineering)</b> <b>Keynote 12:</b> Dr.L.R.Ranganath, Scientist E, CWPRS <b>Parallel Session-12: 10 papers</b>
<b>12:30 pm to 01:10 pm</b>	<b>Invited Speaker -6</b> Prof. Xianon Tang, Xi'an Jiaotong-Liverpool University, China
<b>01:10 pm to 02:00 pm</b>	<b>BREAK</b>
<b>02:00 pm to 02:40 pm</b>	<b>Invited Speaker -7</b> Prof. Nigel Wright, Deputy Vice-Chancellor for Research and Enterprise at Nottingham Trent University, UK
<b>Six Parallel Sessions</b> <b>02:40 pm to 05:50 pm</b>	<b>Server 1: (Theme : Groundwater Modelling and Management)</b> <b>Keynote 13:</b> Prof. P.C. Swain, VSSUT, Burla

	<p><b>Parallel Session-13: 10 papers</b></p> <p><b>Server 2: (Theme : Computational Fluid Dynamics / Numerical Modelling)</b></p> <p><b>Keynote 14:</b> Prof. Sunil Ku. Sarangi, Ex Professor, IIT Kharagpur</p> <p><b>Parallel Session-14: 10 papers</b></p>
	<p><b>Server 3: (Theme : Sediment Transport)</b></p> <p><b>Keynote 15:</b> Er. Jyotirmaya Rath, EIC, WR, Odisha</p> <p><b>Parallel Session-15: 10 papers</b></p>
	<p><b>Server 4: (Theme : River Hydraulics)</b></p> <p><b>Keynote 16:</b> Prof. K V Jaykumar, NIT Warangal</p> <p><b>Parallel Session-16: 10 papers</b></p>
	<p><b>Server 5: (Theme : Urban Water Management/ Irrigation Management)</b></p> <p><b>Keynote 17:</b> Prof. A. K. Gosain, IIT Delhi</p> <p><b>Parallel Session-17: 10 papers</b></p>
	<p><b>Server 6: (Theme : Hydrometeorology)</b></p> <p><b>Keynote 18:</b> Prof. R Maity, IIT Kharagpur</p> <p><b>Parallel Session-18: 10 papers</b></p>
<b>05:50 pm to 06:30 pm</b>	<p><b>Invited Speaker -8</b></p> <p><b>Prof. Pradeep K. Behera, Professor Chair, University of District of Columbia, Washington DC, USA</b></p>

**NB: All times mentioned are in Indian Standard Time (IST)**

<b>DAY-3</b> <b>28<sup>th</sup> March, 2021 (Sunday)</b>	
<b>08:00 am to 8:40 am</b>	<b>Invited Speaker -9</b> Prof. Ashok Mishra, Clemson University, USA
<b>08:40 am to 09:20 am</b>	<b>Invited Speaker -10</b> Prof. Debabrata Sahoo, Sustainable Water Resources, Clemson University, USA
<b>9:20 am to 09:40am</b>	<b>BREAK</b>
<b>Six Parallel Sessions</b> <b>09:40 am to 12.50 pm</b>	<b>Server 1: (Theme: Hydraulic &amp; Hydrologic Modelling)</b> <b>Keynote 19:</b> Prof. Manas R. Behera, IIT Mumbai <b>Parallel Session-19: 10 papers</b>
	<b>Server 2: (Theme: Hydraulic &amp; Hydrologic Modelling)</b> <b>Keynote 20:</b> Prof. Subba Rao, NIT Surathkal <b>Parallel Session-20: 10 papers</b>
	<b>Server 3: (Theme: RS/GIS Application for Water Resources Management)</b> <b>Keynote 21:</b> Prof. V. Jothiprakash, IIT Bombay <b>Parallel Session-21: 10 papers</b>
	<b>Server 4: (Theme: Soft Computing Techniques in Water Resources)</b> <b>Keynote 22:</b> Prof. D. P. Acharya, NIT Rourkela <b>Parallel Session-22: 10 papers</b>
	<b>Server 5: (Theme: Hydraulic Structures and Hydropower Engineering)</b> <b>Keynote 23:</b> Er. Ashutosh Dash, CE cum Additional Secretray Deptt. of Water Resources, Govt. of Odisha <b>Parallel Session-23: 10 papers</b>
	<b>Server 6: (Theme: Groundwater Modelling and Management)</b> <b>Keynote 24:</b> Prof. Rajib Bhattacharya, IIT Guwahati <b>Parallel Session-24: 10 papers</b>
<b>12:50 pm to 1:20 pm</b>	<b>BREAK</b>
<b>Five Parallel Sessions</b>	<b>Server 1: (Theme: Hydraulics and Hydrologic Modelling )</b>

<b>1:20 pm to 3:50 pm</b>	<b>Parallel Session-25: 10 papers</b>
	<b>Server 2: (Theme: CFD/Numerical Modelling)</b> <b>Parallel Session-26: 10 papers</b>
	<b>Server 3: (Theme: Hydraulics, Hydrology and Water Quality Modelling)</b> <b>Parallel Session-27: 10 papers</b>
	<b>Server 4: (Theme: Hydrometeorology)</b> <b>Parallel Session-28: 10 papers</b>
	<b>Server 5: (Theme: Hydrometeorology, Water Resources Management and Soft Computing)</b> <b>Parallel Session-29: 10papers</b>
	<b>Server 6: (Theme: Hydrodynamics and River Engineering)</b> <b>Parallel Session-30: 09 papers</b>
<b>3:50 pm to 4:20 pm</b>	<b>BREAK</b>
<b>4:20 pm to 5:00 pm</b>	<b>PANEL DISCUSSION &amp; CONCLUDING SESSION</b>
<b>5:00 pm to 6:00 pm</b>	<b>VALEDICTORY SESSION</b>

**NB: All times mentioned are in Indian Standard Time (IST)**

## INVITED TALKS

DAY-1 26 <sup>th</sup> March, 2021		
<b>11:45 am to 12.25pm</b>		<p style="text-align: center;"><b>Prof. Sameh Kantoush</b> Associate Professor, Disaster Prevention Research Institute (DPRI), Kyoto University, Japan. Topic: Integrated Reservoir Sediment Management at the River Basin for Sustainable Water Resources Management</p>
<b>12:45 pm to 01:25 pm</b>		<p style="text-align: center;"><b>Dr. Sebastien Proust</b> Researcher, French National Institute for Agriculture, Food, and Environment (INRAE), France. Topic: Large-scale structures in transversally sheared open channel flows.</p>
<b>05:30 pm to 6:10 pm</b>		<p style="text-align: center;"><b>Prof. Hanif Chaudhry</b> Professor, Department of civil and environmental engineering, college of Engineering and Computing, USA. Topic: How Reliable are the Results of Transient-Flow Models?</p>
<b>06:10 pm to 06:50 pm</b>		<p style="text-align: center;"><b>Prof. Chittaranjan Ray</b> Professor and Director of Nebraska Water Center, Department of civil and environmental engineering, university of Nebraska- Lincoln, USA. Topic: How best to manage Odisha's water resources for economic growth and future sustainability?</p>

**DAY-2**  
**27<sup>th</sup> March, 2021**

<p><b>08:30 am to 09:10 am</b></p>		<p><b>Prof. Evan Davis</b> Associate Professor, Water Resources Engineering, Department of civil and environmental engineering, University of Alberta, Canada. Topic: A Systems Approach to Water Resources Planning and Management</p>
<p><b>12:30 pm to 01:10 pm</b></p>		<p><b>Prof. Xiaonon Tang</b> Associate Professor, Xi'an Jiaotong-Liverpool University, China. Topic: Analytical modelling for predicting the flow velocity in vegetated channels</p>
<p><b>02:30 pm to 02:40 pm</b></p>		<p><b>Prof. Nigel Wright</b> Deputy Vice-Chancellor for Research and Enterprise at Nottingham Trent University, United Kingdom. Topic: A novel means for identifying flood sources in urban areas to support the implementation of sustainable urban flood resilience.</p>
<p><b>05:50pm to 06:30pm</b></p>		<p><b>Prof. Pradeep K. Behera</b> Professor Chair, University of the District of Columbia, Washington DC, USA. Topic: Engineering of Urban Water Systems for 21<sup>st</sup> Century and Beyond for India – Challenges and Opportunities</p>

**DAY-3**

**28<sup>th</sup> March, 2021**

<p><b>08:00am to 08:40am</b></p>		<p><b>Prof. Ashok Mishra</b> Associate Professor, Clemson University, USA. Topic: Hydro climate extremes: Compound drought and heatwaves.</p>
<p><b>08:40 am to 09:20am</b></p>		<p><b>Prof. Debabrata Sahoo</b> Associate Professor, Sustainable Water Resource's engineering, Clemson University, USA. Topic: Digital water- The technological wave to manage, analyse, and inform hydrologic assets.</p>

## KEYNOTE TALKS

DAY-1 26 <sup>th</sup> March, 2021		
<p><b>Parallel session 1/ Server-1 (02:20 pm to 03:00 pm)</b></p>		<p style="text-align: center;"><b>Prof. M. C. Deo</b> Professor, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai-400076. Topic: Future shoreline erosion and sea level rise at some of the Indian coastal locations</p>
<p><b>Parallel session 2/ Server-2 (02:20 pm to 03:00 pm)</b></p>		<p style="text-align: center;"><b>Dr.R.N Sankhua</b> Chief Engineer at Ministry of Jal Shakti (WR, RD &amp; GR) - Govt of India Hyderabad, Telangana, India. Topic: Hydroinformatics and Hydro-Diplomacy in Shaping the Sapiency for Troubled Waters of Mahanadi</p>
<p><b>Parallel session3/ Server-3 (02:20 pm to 03:00 pm)</b></p>		<p style="text-align: center;"><b>Prof. T. I. Eldho</b> Institute Chair Professor, Department of Civil Engineering, Indian Institute of Technology Bombay, Powai, Mumbai-400076. Topic: Climate Change and Land Use Impact Assessment on Hydrology- A Regional Scale Approach</p>
<p><b>Parallel session4/ Server-4 (02:20 pm to 03:00 pm)</b></p>		<p style="text-align: center;"><b>Prof. C. S. P. Ojha</b> Professor, Department of Civil Engineering, Indian Institute of Technology, Roorkee, Uttarakhand, 247667, India. Topic: Evolution of Rainfall-Runoff Models.</p>

<p><b>Parallel session 5/ Server-5 (02:20 pm to 03:00 pm)</b></p>		<p><b>Prof. D. Nagesh Kumar</b> Chairman, Centre for Earth Sciences (CEaS) Professor, Department of Civil Engineering, Associate faculty, Interdisciplinary Centre for Water Research (ICWaR) IISc Bangalore, India. Topic: Remote Sensing and GIS for Flood Inundation Mapping</p>
<p><b>Parallel session 6/ Server-6 (02:20 pm to 03:00 pm)</b></p>		<p><b>Prof. Subashisa Datta</b> Professor, Department of Civil Engineering, Indian Institute of Technology Guwahati, Assam, India 781039. Topic: Complexities in Urban Hydrological Modelling: Research Progress and Future Directions</p>

**DAY-2**

**27<sup>th</sup> March, 2021**

<p><b>Parallel session 1/ Server-1 (09:20 am to 10:00 am)</b></p>		<p><b>Prof. Dwarakish G. S.</b> Professor, Department of Applied Mechanics &amp; Hydraulics, National Institute of Technology Surathkal, Karnataka, India 575025. Topic: Geoinformatics in Coastal and Ocean Engineering</p>
<p><b>Parallel session 2/ Server-2 (09:20 am to 10:00 am)</b></p>		<p><b>Prof. P. L. Patel</b> Professor, Department of Civil Engineering, Sardar Vallabhai National Institute of Technology Surat, Gujarat, India. Topic: Impact of Climate Variability on Water Security of Tapi Basin.</p>
<p><b>Parallel session 3/ Server-3 (09:20 am to 10:00 am)</b></p>		<p><b>Dr. Chintalacheruvu Madhusudana Rao</b> Associate Professor, Department of Civil Engineering, National Institute of Technology, Jamshedpur, India. Topic: Application of simplified routing methods for hydrometric data-based real-time flood forecasting</p>
<p><b>Parallel session 4/ Server-4 (09:20 am to 10:00 am)</b></p>		<p><b>Prof. Pranab Kumar Mohapatra</b> Professor, Department of Civil Engineering, Indian Institute of Technology Gandhinagar, Ahmadabad, Gujarat, India. Topic: Detection of Partial Blockage In Piping System</p>

<p><b>Parallel session 5/ Server-5 (09:20 am to 10:00 am)</b></p>		<p><b>Prof. Venkappayya R. Desai</b> Professor, Department of Civil Engineering, Dean, Faculty of Engineering and Architecture (FoE&amp;A) Indian Institute of Technology Kharagpur, West Bengal, India. Topic: Sustainable water management through promotion of voluntary afforestation</p>
<p><b>Parallel session 6/ Server-6 (09:20 am to 10:00 am)</b></p>		<p><b>Dr.L.R. Ranganath</b> Scientist “E”, Central Ward and Power Research Station. Ministry of Jal Shakti, Department of Water Resources. Topic: Evaluation of a navigational channel in Tapi estuary through model studies</p>
<p><b>Parallel session 1/ Server-1 (02:40 pm to 03:20 pm)</b></p>		<p><b>Prof. Prakash Chandra Swain</b> Department of Civil Engineering, Veer Surendra Sai University of Technology, Burla, Odisha, India. Topic: Flood management in tropical countries with special reference to medium and small catchments</p>
<p><b>Parallel session 2/ Server-2 (02:40 pm to 03:20 pm)</b></p>		<p><b>Prof. Sunil Kumar Sarangi</b> Former Ex Professor, Indian Institute of Technology Kharagpur, West Bengal, India. Topic: An Overview of Industrial Water Supply Systems</p>
<p><b>Parallel session 3/ Server-3 (02:40 pm to 03:20 pm)</b></p>		<p><b>Er. Jyotirmaya Rath</b> Engineer in Chief, Water Resources, Bhubaneswar. Topic: Shoreline protection for Odisha coast with a Case study on Geo-tube embankment at Pentha in Kendrapara District</p>

<p><b>Parallel session 4/ Server-4 (02:40 pm to 03:20 pm)</b></p>		<p><b>Prof. K. V. Jayakumar</b> Professor, Department of Civil Engineering, National Institute of Technology Warangal, Telangana. Topic: Modelling of environmental flow requirements using hydrological and habitation models</p>
<p><b>Parallel session 5/ Server-5 (02:40 pm to 03:20 pm)</b></p>		<p><b>Prof. A.K. Gosain</b> Professor, Department of Civil Engineering, Indian Institute of Technology Delhi, India. Topic: Recipe of Achieving Water Security and Sustainable Development of India</p>
<p><b>Parallel session 6/ Server-6 (02:40 pm to 03:20 pm)</b></p>		<p><b>Dr. Rajib Maity</b> Associate Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, West Bengal, India. Topic: Temporal Networks-Based Approach for Non-stationary Hydro-climatic Modelling.</p>

**DAY-3**

**28<sup>th</sup> March, 2021**

<p><b>Parallel session 1/ Server-1 (09:40 am to 10:20 am)</b></p>		<p><b>Dr Manas Ranjan Behera</b> Professor, Department of Civil Engineering, Indian Institute of Technology Bombay, India. Topic: Coastal Vulnerability in a Changing Climate</p>
<p><b>Parallel session 2/ Server-2 (09:40 am to 10:20 am)</b></p>		<p><b>Prof. Subba Rao</b> Professor, Department of Water Resources &amp; Ocean Engineering, National Institute of Technology Surathkal, Karnataka, India. Topic: Analysis of coastal erosion problems in the vicinity of Netravathi-Gurpur river estuary, west coast of India- a modelling approach</p>
<p><b>Parallel session 3/ Server-3 (09:40 am to 10:20 am)</b></p>		<p><b>Prof. V. Jothiprakash</b> Professor, Department of Civil Engineering, Indian Institute of Technology Bombay, India. Topic: Sedimentation rate and behavior analysis using chaos theory</p>
<p><b>Parallel session 4/ Server-4 (09:40 am to 10:20 am)</b></p>		<p><b>Dr. Debiprasad Priyabrata Acharya</b> Professor, Department of Electronics and Communication Engineering, National Institute of Technology Rourkela, Odisha. Topic: Intelligent IoT for Water Resource Management</p>
<p><b>Parallel session 5/ Server-5 (09:40 am to 10:20 am)</b></p>		<p><b>Er. Ashutosh Dash</b> CE cum Additional Secretary Dept. of Water Resources, Govt. of Odisha Topic: Uttarakhand flood – 2021: Reasons and lessons to learn</p>

**Parallel session 6/  
Server-6  
(09:40 am to 10:20  
am)**



**Prof. Rajiv Bhattacharya**  
Professor, Department of Civil Engineering,  
Indian Institute of Technology Guwahati, India.  
Topic: Status and Management of Groundwater  
in India

## **ABSTRACTS OF INVITED TALKS**

Invited Speaker-1

## Integrated Reservoir Sediment Management at the River Basin for Sustainable Water Resources Management

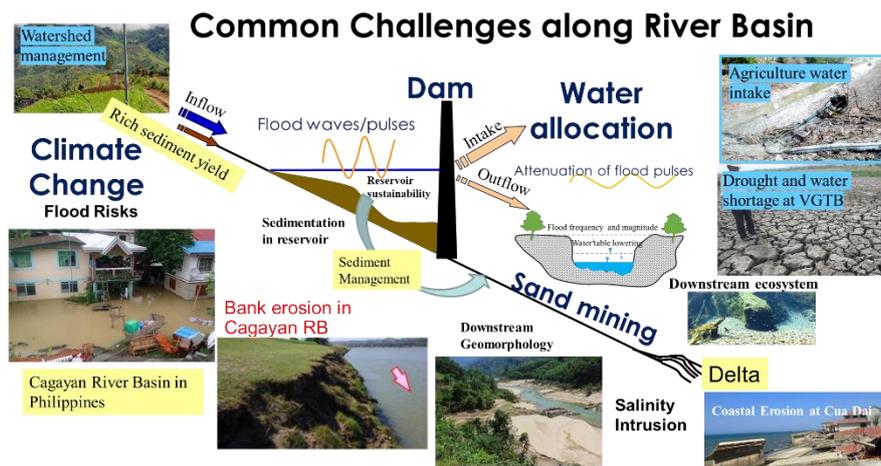
Sameh A. Kantoush<sup>1</sup>

<sup>1</sup>Water Resources Research Center, Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan

Email: [kantoush.samehahmed.2n@kyoto-u.ac.jp](mailto:kantoush.samehahmed.2n@kyoto-u.ac.jp)

### Abstract

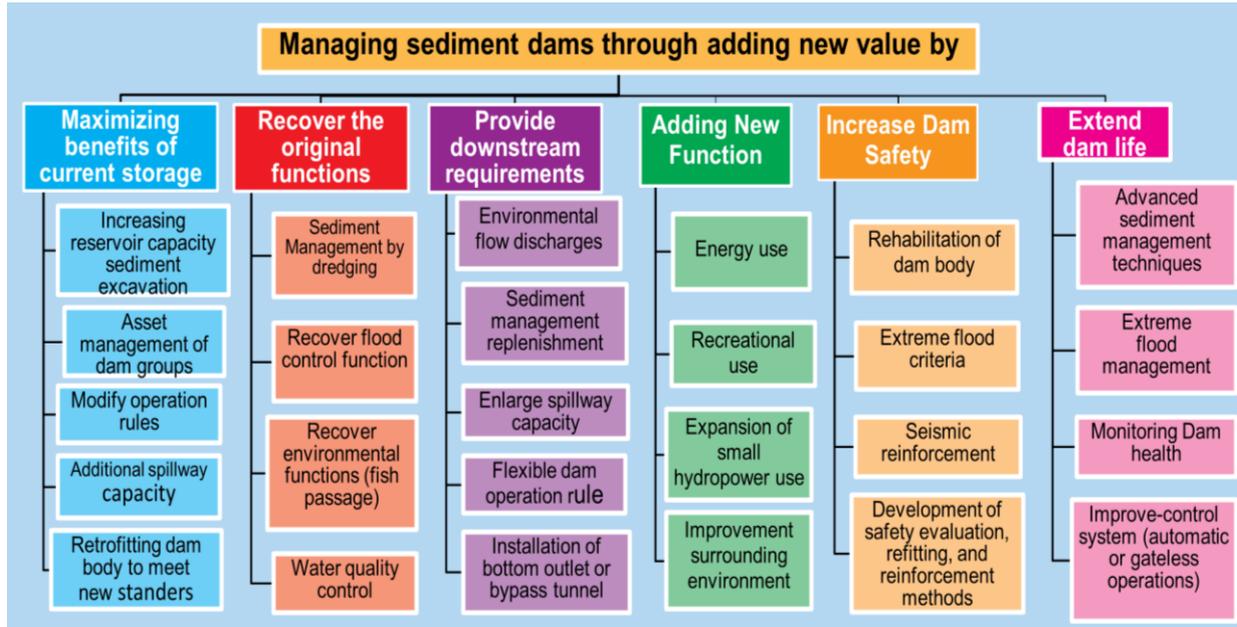
Sedimentation is one of the most crucial issues jeopardizing the sustainability of reservoirs. Integrated reservoir sediment management must include management of both the flow and sediment phases at the river basin scale from watershed until delta. It is very important to recognize that various challenges affect the river basin systems (Figure 1) due to anthropogenic and climate change effects, in both developed or developing countries. Siltation in reservoirs causes a significant reduction of the original storage capacity and deterioration of the river ecosystem. The ramifications of inefficient sediment management extend to socio-economic issues, environmental impact, and navigational concerns. Efficient transportation of the sediment deposited in a reservoir behind a dam to the downstream of a river reach is instrumental for preserving the ecosystem. It is, therefore, imperative to implement necessary sediment management technique, such as flushing, sediment bypass tunnel, sluicing and dredging, to restore the dam function and recover the ecosystem at dam sites.



**Fig. 1:** Challenges and problems facing the river basins as a consequence of dam constructions and changing climate

In this article, we present challenges for sedimentation in the Japanese reservoirs, provide an overview of reservoir and sediment management in Japan, introduce recent agendas for integrated river basin, and present three key sediment strategies as case studies in more detail. Figure 2 present a new paradigm shift for management of dam and sediment to secure water resources development in the river basin scale. By adding new value to the existing dam, such as flood control and disaster risk reduction, rehabilitation, upgrading and retrofitting activities have to be implemented. We will list some of these methods to support dam upgrading and retrofitting:

1. Improving the hydropower functions and generating electricity from non-powered dams;
2. Increasing the capacity of the reservoirs by excavating/dredging the deposited sediments;
3. Increasing flood discharges by improving discharge facilities and adding new outlet;
4. Increasing dam height will add extra effective storage for flood control or other purposes;
5. Exchange reservoir storage functions among group of dams by linking several single adjacent dams in the basin so that the storage capacity can be effectively used;
6. Modify reservoir operation rules by preliminary drawdown water level in the reservoir and keep it flexible during flood period. Thus, by increasing flow volumes, an additional reservoir storage capacity will be guaranteed;
7. Increase dam safety and ability of the dam body to resist earthquake and other disasters;
8. Improving the existing functions for recreation and amenities;



**Fig. 2** Sediment management diagram for necessity of adding new values for a sustainable water resource management

In this lecture I will highlight the dire for paradigm shifting for dam’s water and sediment management in the river basin scale, and approach to design effective sediment management strategies. The latter is required to build future dams, maintain reservoir functions of existing dams, and contribute to total basin scale development. Numerous dams are malfunctioned with tens of thousands of sediment deposition volumes in deep, middle, and upstream tail-water parts of the reservoir. There are various sediment management methods suitable for each zone of the reservoir as excavating, dredging, bypassing, flushing, and sluicing.

These methods often compete, and one of the most common trade-offs involves choosing between no action or recovering dam function and extending dam life. At the beginning various options for sediment management are available. With no action measured in 100 years the excavation cost will be extremely high and often times unfeasible. Comparatively, installation of sediment bypass tunnel would yield significantly less sediment deposition rate. Combining both measures alternatively, would recover reservoir functionality and extend the dam’s life. Implementation of these strategies is deemed prudent for recovery after 10, 20, 30, 50, 100 years is crucial for project recovery. Sediment management necessitates performing economic feasibility studies for the recovery method in consideration.

The costs and benefits of asset management in coordination with changes in dam and downstream should be in perspective during decision making. To this end, a new concept and methodology should be conceived a priori to design an intergenerational, sustainable, self-supporting rehabilitation system for river basins with reservoirs. Measuring the benefits and costs of an improvement in water quality is often difficult. For efficient integrated sediment management in the river basin, it is necessary to find a balance between flow and sediment release. Further work is needed to guide the future management of aging dams around the world and support the huge investment decisions that will have to be made.

## Large-Scale Structures in Transversally Sheared Open Channel Flows

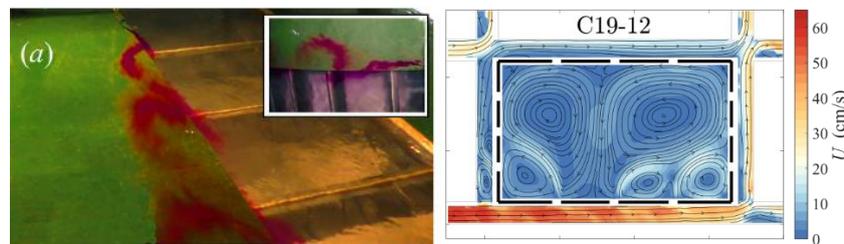
Sébastien Proust<sup>1</sup>

<sup>1</sup>Researcher, French National Institute for Agriculture, Food, and Environment (INRAE), France

Email: <sup>1</sup>sebastien.proust@inrae.fr

### Abstract

Shallow flows can be defined as 'predominantly horizontal flows in a fluid domain for which the two horizontal dimensions greatly exceed the vertical dimension' (Jirka, 2001). Shallow water flows can be encountered e.g., in rivers, lakes, and along the coastline, and shallow airflows are observed e.g., within the first layer of the earth's atmosphere, the troposphere. In the case of shallow open-channel flows, the base flow is partly driven by the three-dimensional (3-D) turbulence induced by the channel bed and sidewalls. This 3-D turbulence involves various types of turbulent coherent structures: sweep and ejection events (from the solid walls) for which the length scale is lower than (or equal to) the flow depth  $h$  (Nezu & Nakagawa, 1993); turbulent Large Scale Motions (LSMs) and Very Large Scale Motions (VLSMs) that have been recently observed in rough-bed open-channel flows by Cameron et al. (2017) and Zampiron et al. (2020), which are meandering long streamwise counter-rotating vortices, and whose length scale in the streamwise direction can be of the order of  $10h$  to  $100h$ , respectively (see Cameron et al., 2017, figure 5).



**Figure 1:** (Left) Development of turbulent coherent structures (KHCSs) in compound open channel flow (Proust & Nikora 2020). (Right) Recirculating mean flow cells with a vertical axis, for urban flood flows (Mejia et al., 2020)

When subject to topographical singularities (e.g., natural levees, dikes, two-stage channels, causeway, islands) or/and to lateral changes in bed roughness, shallow open-channel flows are transversely sheared. The transversely sheared flows (including e.g., shallow wakes, jets and mixing layers) can involve internal instabilities in the spanwise profile of the time-averaged streamwise velocity. These instabilities can subsequently give rise to the emergence and development of large-scale two-dimensional coherent structures (2DCSs). The latter are defined by Jirka (2001) as 'connected, large-scale turbulent fluid masses that extend uniformly over the full water depth and contain a phase-correlated vorticity (with the exception of a thin near-bottom boundary layer)'. Among these 2DCSs, some vortical structures are generated by a significant inflectional instability in the time-averaged velocity profile (Huerre & Rossi, 1998), termed Kelvin-Helmholtz instability. The 2DCSs emanating from this instability are logically termed Kelvin-Helmholtz-type coherent structures (KHCSs).

The focus of the present keynote lecture is on the emergence and development of large-scale structures in transversally sheared open-channel flows, and on the interplay between structures. Both large-scale turbulent coherent structures (such as KHCSs, LSMs and VLSMs) and time-averaged flow structures (helical secondary currents with a longitudinal axis, and recirculating flow cells with a vertical axis) will be investigated. Four flow configurations (explored in the Hydraulics and Hydro-morphology Lab – HHLab\* of INRAE, Lyon-Villeurbanne, France) have been chosen:

- Depth-uniform and non-uniform flows in a compound open-channel, relying on the experiments of Proust & Nikora (2020) and their simulations by Chatelain & Proust (2020)
- Shallow mixing layers over a rectangular smooth bed (Proust, Berni, Nikora, 2020)
- Open-channel flows through emergent rigid vegetation under steady flow conditions (Dupuis et al., 2016) or unsteady flow conditions (Khuntia, Proust, Khatua, 2020)

Urban flood flows, relying on the experiments of Mejia et al. (2020), and Mejia et al, under review for J. of Hydrology.



Invited Speaker-3

## How Reliable are the Results of Transient-Flow Models?

**M. Hanif Chaudhry**

*Associate Dean (International Programs) College of Engineering and  
Computing University of South Carolina, Columbia, SC*

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### Abstract

With the availability of digital computers since the 1960, computer models have been developed to simulate various flows, starting from simple one-dimensional flows to complex unsteady, three-dimensional flows in open channels, pipes and sub-surface flows. Although significant advances have been made in the development of efficient numerical methods and post-processing of computed results, the basic algorithmic part of the computer codes unfortunately have received limited attention.

This presentation covers transient flows (intermediate flow between two steady states), both in open channels and in pressurized conduits. Mostly, one-dimensional flows are considered.

To develop a computer model, equations governing the flows are solved. A number of simplifying assumptions are made in the derivation of the governing equations. These equations are usually non-linear and closed-form solutions are not available. Therefore, numerical methods are employed for their solution. Depending upon the numerical method, some convergence and stability conditions may have to be satisfied.

The results of such computer models are accurate and reliable if the simplifying assumptions on which the governing equations are based are satisfied, any stability or convergence conditions are met and the system data is appropriate and precise. This is demonstrated by a number of applications of the computer models to real-life projects, showing both successes and failures and indicating that using the computer model as a black box can be disastrous.

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Invited Speaker-4

## How best to manage Odisha's water resources for economic growth and future sustainability?

**Dr. Chittaranjan Ray<sup>1</sup>**

*<sup>1</sup>Director, Nebraska Water Center*

*Professor, Department of Civil & Environmental Engineering, University of Nebraska, Lincoln, Nebraska, USA*

*Email: [cray@nebraska.edu](mailto:cray@nebraska.edu)*

### Abstract

The major east flowing rivers of Odisha drew national attention in pre-independence India due to the impacts of severe floods on coastal populations. Even Mahatma Gandhi was moved by the flood misery of the generally poor rural population though his contacts with Gopabandhu Das and Gandhiji advised the state to receive the advice of Engineer M. Viswesaraya to find a solution. The severe flood of 1943 prompted the era of dam construction. Started in 1948 and completed in 1957, Hirakud Dam became the first multi-purpose dam in post-independence India. Benefits included flood control, power generation, irrigation, and ancillary ones like fisheries and recreation. With time, other projects (Balimela, Kolab, Rengali, Indravati, etc.) followed with various priorities. As many of these multi-purpose projects are on inter-state rivers, water and power sharing agreements were needed. Such issues are contentious and disagreements lead to litigation, which often drags on for decades. As we are entering into a carbon-neutral digital economy, the value of large dams is being questioned due to costs, ecological impacts, displacement of people from submerged areas, and solar or wind energy at places outcompeting hydropower costs, including operation and maintenance. However, irrigation needs for food security cannot be discounted.



Food security for the growing global population is civilization's next critical challenge. As the current world population of seven billion increases to more than nine billion in the next three decades and more families move to the "middle" income group, preference is changing to more meat-based food. As individual calorie intake rises, so too will the demand for food and feed for animals. Sustaining a high rate of food production will require improving water productivity, use of hybrids and fertilizers, and cheaper energy sources for irrigation and other agricultural activities. Most developing countries are far below their agronomic yield potential for major food crops. Large-scale efforts need to be undertaken to reduce the yield gaps (difference between the current yield and potential maximum yield) of major staple crops. Western researchers and philanthropic organizations are working on future food needs of food-insecure countries by examining the magnitude of the yield gap, such as the Global Yield Gap Atlas project (<http://www.yieldgap.org/>). Developed economies see enhancement of food production with high-efficiency irrigation systems, high yielding and disease resistant crop varieties, supplemented by appropriate fertilization, the use of plant protection chemicals, and overall efficient management of farm operations. Simulation models bridging many disciplines are being developed in the cyber domain to estimate crop growth and yield, irrigation water quantity and quality dynamics, surface-ground water interaction, and energy use. These models have the potential to address sustainability concerns such as: Can food production be increased over the next several decades sustainably without significantly affecting the quantity and quality of ground and surface water? How can energy use in agriculture reduce the carbon footprint on the earth (e.g., energy for irrigation, fertilizers, plowing, machinery etc.)? Will food production methods fitting these criteria be bold enough to withstand climatic variations such as long drought or drought after flood in the same season? What can be done to integrate data collection and modeling to better manage the production systems? The Green Revolution helped many developing countries to achieve yield increases because of the availability of high-yield cultivars, irrigation water, fertilizers, as well as plant protection chemicals. India seems to be self-sufficient in food production and rarely imports staple food crops in recent decades. However, given its population is expected to grow from the current 1.34 billion to 1.66 billion in 2050, will India be able to maintain its food self-sufficiency in the coming decades and if so at what cost?

This presentation will examine key water sustainability concerns in the context of irrigation and food production for Odisha and discuss measures that can be taken up at local scales to manage water resources in a sustainable manner for future economic growth. The presentation will also discuss energy for agriculture and digital/cyber technologies to enhance yield and producer profitability.

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Invited Speaker-5

## **A Systems Approach to Water Resources Planning and Management**

**Dr. Evan G. R. Davies**

*Associate Professor, Civil and Environmental Engineering, University of Alberta, Canada*

*Email: [edavies1@ualberta.ca](mailto:edavies1@ualberta.ca)*

### **Abstract**

Water resources are under increasing pressure from population and economic growth, uneven resource distribution, and climate change. Currently, approximately two-thirds of the global population lives under conditions of severe water-scarcity for at least one month of the year, making improved water management critical for long-term sustainability. Unfortunately, many such management efforts focus primarily on hydrological processes and incorporate key socio-economic and broader environmental changes as scenarios, or external drivers. Yet, it is actually the interactions between hydrological and socioeconomic processes that are key in determining changes in water systems, and their sustainability, from local to global scales. Systems approaches offer a means of both increasing our understanding of water resources problems, and of developing and evaluating appropriate infrastructure and management strategies. A particular approach called "system dynamics" simulates the behaviour of complex systems. As a philosophy, system dynamics (SD) asserts that observed events stem from unforeseen interactions between the various components inside a system of interest. From the perspective of system dynamics, the world is characterised by feedback-loops: causes lead to effects, which then become causes in turn. As explained by Richmond (1993: 118), SD means "a shift from viewing the world as a set of static, stimulus-response relations to ... an ongoing, interdependent, self-sustaining, dynamic process". SD therefore focuses on identifying and understanding the internal stock-and-flow and feedback structures within a system of interest that gives rise to its observed behaviour.



As a simulation modelling methodology, SD represents feedback connections between key model elements both mathematically and diagrammatically, and uses simulation to gain insight into how system structure and feedback connections determine behaviour. These models aid exploration of the interactions and feedbacks between various subsystems, provide flexible and fast simulation tools, structure present knowledge and help to identify and rank major uncertainties, and supply tools for communication between scientists, the public and policy makers. In my presentation, I will introduce system dynamics and describe two case studies, one for long-range simulations in the Bow River basin in Alberta, Canada, and the other for municipal water demand in the city of Edmonton, Alberta. At a basin scale, the Bow River Integrated Model (BRIM) introduces a comprehensive modelling framework for Integrated Water Resources Management (IWRM). The BRIM includes basin-scale water demands, allocation and uses under various climate, population and economic scenarios as well as management strategies. Model outputs are wide-ranging and include crop yields, municipal water use, power generation, recreational reservoir uses and environmental flows. The model runs at an annual time step to 2040. The second SD model, the Edmonton Water Demand Simulator (EWDS), is a hybrid SD-regression-artificial neural network model that simulates municipal water use at a weekly timescale, beginning in 1995 and ending in 2100. It includes interactions between changes in municipal water demands with population growth, the available water supply, climate change and water conservation policies, and can be used for long-range municipal water demand projections and infrastructure planning. Through a discussion of the systems approach and the two case study models, I make the case for a more comprehensive, integrated approach to understanding and managing water resources.

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Invited Speaker-6

### **Analytical modelling for predicting the flow velocity in vegetated channels**

**Prof. Xiaonon Tang**

*Associate Professor, Xi'an Jiaotong-Liverpool University, China*

Vegetation widely exists in many rivers and wetlands. The existence of vegetation increases the flow resistance and changes the flow velocity distribution. The influence of vegetation on vertical velocity distribution depends on whether vegetation is rigid or flexible, and whether vegetation is submerged or not. As the pre-condition of flow resistance analysis and pollutant mixing process, predicting the velocity profile and lateral velocity distribution is a prerequisite in many river engineering problems involving bank erosion, sediment and pollutant transport, and habitat condition. This talk will introduce how vegetation affects the velocity distribution of vegetated flow. Two analytical models are presented to predict vertical and lateral velocity distribution of open-channel flow with vegetation. The models are compared with a wide range of different data to evaluate the performance of the models. First, based on the mixing length concept of turbulent eddy, an analytical model is proposed to predict vertical velocity profiles for open-channel flow with submerged one-layered vegetation, followed by an analytical model for the vegetated flow with double-layered vegetation. Second, based on Reynolds-averaged Navier–Stokes equations (RANS), an analytical model is developed for the prediction of the lateral distribution of depth-averaged velocity in a vegetated channel, which includes single and compound channels. The models provide a tool for the flow analysis and application for river water environment.

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Invited Speaker-7

## **A Novel Means for Identifying Flood Sources in Urban Areas to Support the Implementation of Sustainable Urban Flood Resilience**

**Nigel Wright**

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### **Abstract**

Delivering flood resilience in urban areas requires an integrated approach due to the complex social and physical infrastructure in cities. Spatial planning to deliver this still faces challenges in managing stormwater and its interaction with different infrastructure systems. In this presentation a source-to-impact flood analysis system will be presented to identify both the most significant sources of flooding and the most significant areas impacted by the flooding. This can then be used to identify the areas where interventions across infrastructure systems will deliver maximum benefit. This approach will be demonstrated through particular case studies.

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Invited Speaker-8

## **Engineering of Urban Water Systems for 21<sup>st</sup> Century and Beyond for India – Challenges and Opportunities**

**Pradeep K Behera<sup>1</sup>**

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### **Abstract**

As per United Nation's estimate, India's urban population is expected to grow from 410 million in 2014 to 814 million by 2050. According to 2011 census, 31% people live in urban areas. By 2025, 46% of Indians will live in cities with more than 1 million and by 2030, the number of cities with populations of more than 1 million will grow from 42 to 68. This ongoing population growth leads to continuous urbanization which resulted in transformation of natural watersheds into urbanized and/or urbanizing watersheds. Urbanization not only creates impervious areas including buildings, roads, parking lots etc. but also improves the hydraulic efficiency of watershed which significantly alters the hydrology of watersheds affecting the water quantity and quality of receiving waters (i.e., rivers and streams). During rainfall periods, the uncontrolled discharges of stormwater runoff from urban watersheds results in runoff quantity problems such as excessive flooding, streambank erosion and runoff quality problems such as pollutant loading to receiving waters. These receiving waters are the source of potable waters and use water to carry away human and industrial waste for disposal for the towns and cities within the watershed. The availability of quality water over time and space drives the quality of lives for urbanized and urbanizing areas and sustainability of cities which primarily depends upon the urban water systems including water supply systems, sanitary sewer systems, wastewater treatment systems, drainage systems, and urban storm water management. The challenges of Indian cities for future is how to engineer the urban water systems for the current period and for the 21<sup>st</sup> Century.

In order to address the problems from urbanization and associated impacts on the watershed, engineers, planners and water resources professionals from USA and Canada has been implementing various technical approaches over last half century. These approaches require collaboration from a wide variety of disciplines including engineering, environmental and biological sciences, economics, sociology, law and ethics. Most of the water management practices prior to 1970s sought to solve single, localized problems without taking accounts of



the impacts of these actions on biophysical, economic and social elements of larger watershed systems. Over last half century, there has been a big paradigm shift from addressing individual problems to addressing water related problems in an integrated urban watershed-based approach, which has provided some promising sustainable solutions. This presentation will examine the current approaches of urban water systems in USA and Canada and how these approaches along with new approaches can be developed for addressing water quantity and quality issues of Indian cities and towns for the 21<sup>st</sup> Century. The author will share his 20 years of practicing engineering experiences in water resources engineering.

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Invited Speaker-9

## Hydro climatic Extremes: Compound Drought and Heatwaves

**Dr. Ashok K. Mishra**

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### Abstract

The increase in global temperature has altered the spatio-temporal pattern of individual extreme events (e.g., drought and heatwave). However, a limited number of studies investigated their compound characteristics in terms of duration, frequency, severity, and spatial extent. This study explores the spatio-temporal changes in compound events that have a significant impact on health, agriculture, economy, and environment around the globe. The compound framework has a key advantage that it can capture the weekly droughts and heatwaves at daily time scale. The results can directly map the critical regions and reveal the dependence between two extreme events (i.e., drought and heatwaves). This study also examines the spatial asymmetry across the globe and the influence of background aridity on compound extremes in a warming climate. This analysis can be extended to inform stakeholders where the coevolution of these extreme events is likely to be higher under climate change. The results of this analysis will aid forecasting efforts and help to improve hazard preparedness and mitigation strategies for the vulnerable regions of the globe.

The overall objective of this presentation is to highlight the spatiotemporal changes in the Compound Drought and Heatwave (CDHW) events at a global scale based on the following research questions: (a) how does the recent increase in temperature influence the CDHW events; (b) Is there a significant increase in the proportion of HW days coinciding with the extreme drought conditions? (c) to identify the regions that show a greater increase in the characteristics of CDHW events, and examine if there is spatial asymmetry associated with such growth at the global and hemispherical scale? (d) whether the background aridity controls the increase in CDHW characteristics at regional to the continental scale; and (e) to provide a mechanistic understanding of the association between the seasonal occurrences of CDHW events and the major modes of climate variability (ENSO, NAO, and PDO).

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Invited Speaker-10

## **Digital Water-The technological wave to manage, analyze, and inform hydrological assets**

**Debabrata Sahoo**

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South Carolina, USA*

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### **Abstract**

The Internet revolution has created an inseparable digital aspect to our society. The digital world includes various electronic devices and systems that help in collecting, compiling, computing, correcting, and communicating data. These datasets help in understanding and informing the world around us. They enable us to predict the future purely based on evidence. The world of water is no exception to the digital revolution. While a plethora of business applications have been created utilizing these datasets, the digital space around water remains very fragmented. Although a vast amount of water datasets is collected by various agencies such as the USEPA, USGS and potentially available to the public, because they are not collected and communicated in a structured way, the data is not easy to access. For example, if one were to simply search online for the population of South Carolina, USA a graph of the population growth and numeric values associated with the graph are immediately displayed. However, if the search was related to the amount of rain that South Carolina experienced in 2020, no such easy-to-read summary is shown. There is an answer to this very question, but the problem lies in the integration of the data.

If all the water data relevant to South Carolina is piped to a single repository, it could become the “Google of SC Water”. Such a one-stop location for all available water data in the state would help in the development of several water-related applications. Many such connected networks would aid in the development of a regional network – “Google of South East Water”. Such networks would aid in the development of many water-related applications such as “Regional Real-Time Flood Predictions”, “Regional Real-Time Drought Predictions”, “Regional Real-Time Water Quality”, “Live-Modeling”, “SMART Stormwater Management”, “Near-Realtime Event Detection”. The information would also help the billion-dollar industries that rely on these predictions such as transportation, healthcare, retail, horticulture, agriculture, fisheries, etc. The infrastructure could also spur several future industries surrounding “Digital Water”. The current talk will focus on some of the early adoptions and applications of digital data for hydrologic assets around data- collection, correction, compilation, computation and consulting by research organizations, local governments and consulting industries. The presentation will provide examples of various applications relevant to regulatory and compliance, development of an intelligent river system, micro-watershed monitoring, and automation. The presentation will also cover some of the emerging technologies such as machine learning, cloud computing, Internet of Things, blockchains and their integration in solving some of the challenges around Digital Water.

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## **ABSTRACTS OF KEYNOTE TALKS**



Keynote Speaker-1

## Future shoreline erosion and sea level rise at some of the Indian coastal locations

**Prof. M C Deo**

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### Abstract

Around 90 percent of the coasts of India are either sandy, marshy or have large mud flats, and hence remain susceptible to erosion and shoreline change caused by dynamic changes in waves, wind, tides, currents and sea levels. Of recent origin, the long term rise in the mean sea level and changes in the coastal environment both created by global warming have exacerbated the shifting of shorelines towards the land side. The determination of long-term shoreline change can be done directly through satellite imageries or field surveys while such change can be estimated by numerical shoreline models based on short term coastal dynamics or alternatively, by the use of empirical Bruun's rule targeted on the sea level rise (SLR). Owing to the difference in time scales of coastal dynamics and the SLR, a single model involving both is difficult to have. The past works were therefore made on the basis of either of these two drivers. In order to understand how far the simple Bruun's rule-based shoreline change is indicative of the same produced by rigorous numerical models, we evaluated the change using both the methods and compared their results. The locations of the study were the beaches nearby Mumbai and Chennai ports. The specialty of this work was that future predictions belonged to coastal dynamics derived from a regional climate model: REGCM-4 run for medium (RCP-4.5) as well as severe (RCP-8.5) global warming scenarios. It was found in the end that the results of both methods were comparable to each other and hence the simple Bruun's rule could be seen as indicative of the outcome of the exhaustive numerical model. In another study we predicted the SLR and resulting shore retreat at a series of locations along the Indian coastline. The segments of beaches of certain lengths near 13 major ports were considered. The future SLR was predicted on the basis of an ensemble of general circulation models (GCMs) corresponding to medium as well as severe global warming scenarios. It was found that the rate of absolute SLR would be in the range 3.38–5.16 mm/year for the medium and 5.36–7.2 mm/year for the severe warming scenario by the turn of this century. The shoreline recession in response to these SLRs evaluated using Bruun's rule indicated that the future recession of shorelines at these coastal stretches might vary between 14.10–29.22 m and 21.05–45.40 m for the cases of medium and severe warmings, respectively. In general, as compared to the west coast locations, the east coast sites would undergo smaller areal inundation due to relatively lower SLR and resulting shoreline change. We also evaluated SLR at these major ports as per historical tide gauge observations as well as from satellite-based measurements. Such SLR estimates were compared with those projected into the future and up to the end of the present century as per the medium global warming scenario. The projected SLR data came from the same GCM ensemble database as in the above-mentioned work. The recently collected satellite data showed an accelerated growth of SLR than the one estimated from the past long-term tide gauge data; however, it was found to be more likely that both these rates might be much exceeded in future and could go beyond 5 mm/year. In other studies, we determined the shoreline change at a few important coastal locations along west as well as east coasts of India. We also studied the coastal vulnerability using the coastal vulnerability index based on historical as well as projected climate and socioeconomic conditions for two time slices in the past and in the future. The projected wind, wave, and shoreline changes were simulated under a medium warming scenario. This particular study was done for three different types of coastline, namely uninterrupted, naturally discontinuous, and artificially interrupted coastlines, located along the central west coast of India. The coastal vulnerability index was calculated using 7 physical-geomorphologic and 4 socioeconomic indicators using the technique of analytical hierarchical process. The results showed that the vulnerability at all three coastal segments would increase in future and this may require suitable remedial measures by planners, stakeholders, and port authorities. This study also emphasized the need to use projected climate and socioeconomic data in place of historical information to evaluate the vulnerability of a given coast.



Keynote Speaker-2

## Hydroinformatics and Hydro-Diplomacy in Shaping the Sapiency for Troubled Waters of Mahanadi

**Dr. R. N. Sankhua<sup>1</sup>**

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### Abstract

Vigorously endorsed as a resplendent effort, legitimate water allocation desire of Mahanadi basin is a visible combination of motivated executive aspiration, expionible despatch, and optimum response, all realised under the subtle impeding desideratum of the eminent professionals in recent years, though convoluted with inter-State water-sharing dissonance coupled with wrestle over claims and counterclaims, and assorted social, agricultural, industrial, ecological and economic concerns. The sharp polarization between agriculture and industries over water use is a stark reminder and calls for a sapient water management for the troubled waters of Mahanadi. The question of the survival of over 300,000 farmers and fishermen entirely dependent on Mahanadi has taken a backseat. Potent to the growing water crisis exacerbate the situation and the trampled destinies of poor inhabitants have repeatedly tilted the balance throwing life and property in disarray, costing a fortune. Thrashing out the problem of lack of water for irrigation in one region and distress signals of monsoon flood, damage to crops due to drought and pitiable drainage facility, mounts pressure in the face of depleting and decreasing availability of water resources in the troubled waters of Mahanadi. Ad rem laments on the bilateral opacity between the riparian states on Mahanadi water sharing is plumbing new depths, as water being a vital connector across the people of the states. The complexity of governing the water resources is compounded by the multiplicity of jurisdictions involved and the challenges ahead are formidable. Further, adverse impact on water availability due to erratic rainfall and increased flooding in certain pockets coupled with high rates of population, economic growth, and urbanization would threaten food security, cause dieback of natural ecosystems, and sustenance creates stinks and is back of beyond for the livelihood. Water tensions becoming explosive in the sub-basins, where water resources are scarce and are further exacerbated by the consequences of climate change. Further, leaving the region to its own devices without amiable hydro-diplomacy may be a damp squib in successful basin water management with admixtures of many generalities in-hand sans specific breakthroughs. Convivial dialogue between the riparian states, Odisha and Chhattisgarh with development of a cordial neighbourhood policy incorporating interests of key stake-holders, adaption of better response to mainstream climate impacts, resilience across allocation systems, in-situ capacities at inter-state levels, and Mahanadi basin solution to water sharing predicament can catch the wave. Mahanadi basin water management founded on hydroinformatics with a range of models that agree to use shared datasets, appropriate definitions of water consumption enshrining current climate variability with sufficient hydro-diplomacy can turn this challenge into an opportunity, leapfrog into a process of agricultural, industrial growth that is water-efficient and waste-reductive. At the deplorable backdrop of this, the present keynote talk offers inputs from my professional's perspective and is an attempt to focus hydroinformatics, agreeable hydro-diplomacy, and obstinately with convinced implementation of needed allocation and ecological rejuvenation of Mahanadi waters in a coordinated manner.

Keynote Speaker-3

## Climate Change and Land Use Impact Assessment on Hydrology – A Regional Scale Approach

**Prof. T.I. Eldho<sup>1</sup>**

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### Abstract

In the recent times, it is identified that global warming and climate change will be detrimental for the hydrologic cycle, though the degree of its impact on a regional scale is mostly varying. In most of the regions, along with the



climate change, local variations in land use patterns are linked to the energy fluxes which, ultimately affects hydrologic processes such as surface runoff, streamflow, evapotranspiration, flood regimes and sediment yield. Similarly, the climate change is also capable of inducing land use land cover (LULC) changes. Many studies have identified that, both LULC and climate change, affect hydrological processes. The LULC variations in most of the places arise due to human induced factors aggravated by surging population and over-exploitation of resources. In a country like India, the combined effect of LULC and climate change results in large scale socio-economic impacts as there is no adaptability to such changes. In this study, we used Variable Infiltration Capacity (VIC) hydrologic model to study the historical in climate and LULC changes on surface runoff at regional scale for Tadri to Kanyakumari river basins in Western Ghats of India. The West Flowing River Basins from Tadri to Kanyakumari (WFRB-2) in India is a highly complex hydrological system with around 42 medium and small river basins that has been recently witnessing hydrological extreme events such as the Kerala floods in 2018, landslides and droughts. In this paper, the historical impacts of climate and LULC changes are analyzed for the past 35 years by considering the various phases of LULC changes and the results are presented. The Landsat data was used for historical LULC classification. The hydrologic model was calibrated and validated for various parameters by considering the historical data. The results show important changes in land cover and indicate that urban and agricultural areas strongly influence the surface runoff. Among the land cover and climate change impacts, climate has more predominant impact. The results of such study can be helpful to policymakers for appropriate land use planning and water resource management, in the climate change scenarios.

**Keywords:** Climate Change, Land Use Change, Hydrology, GCM, Surface runoff, VIC model

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Keynote Speaker-4

## Evolution of Rainfall-Runoff Models

**Prof. C.S.P. Ojha<sup>1</sup>**

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### Abstract

The estimation of surface runoff has many applications. During the last few decades, many event-based runoff simulation models or continuous streamflow simulation models have been developed. These models simulate runoff generated from a rain event as per the model development. In event-based rainfall-runoff modeling which simulates runoff without acknowledging base flow, many models exist. The hydrologists prefer a rainfall-runoff model that requires the least input parameters with better runoff prediction (Perrin *et al.* 2001). There are various models available for estimating direct runoff but their applicability is limited in data-scarce catchments due to various reasons such as requirements of several input data, the difference between the spatial scales of the application, and ambiguity in specifying the parameters' values (Gupta *et al.* 2019). The soil conservation services-curve number (SCS-CN) method fulfills this requirement and is often preferred by hydrologists. The original SCS-Curve Number method has also some limitations and misinterpretations. The method has the unstable model structure to flexibly consider storm duration and rainfall intensity, unaccounted static infiltration, incorporating AMC conditions criteria, and fixing of  $\lambda$  (initial abstraction coefficient) value (Baiaomonte 2019). Notably, the antecedent moisture only elucidates inter-event dissimilarity in curve number value and any change in antecedent moisture condition (AMC) affects CN value and invariably sudden jump occurs that generates a quantum jump in runoff estimation (McCuen 2002). In determining the partitioning of event rainfall into event runoff, Beck *et al.* (2009) identified soil moisture as a key component. They suggested that prior to the rainfall event, infiltration and the soil moisture proxies are considered to account for a catchment's wetness status in the hope to improve streamflow prediction. Singh *et al.* (2015) observed the importance of initial moisture in SCS-CN methodology that can avoid sudden jumps. Ajmal *et al.* (2016) illustrated inconsistencies in the initial abstraction ( $I_a$ ) and curve number (CN) and suggested additional changes to the CN and the  $I_a$  in the NRCS model for more accurate runoff estimations. The model lacks theoretical foundation and suffers from numerous structural inconsistencies which require improvement (Rajib and Merwade 2016). In consideration of the above, there is a need of alternate approaches. This lecture will provide an insight into these approaches for better runoff estimation. Case studies



including Indian as well as US-based catchments will also feature. Various rainfall-runoff modelling efforts along with future direction of research will also be highlighted.

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Keynote Speaker-5

## Remote Sensing & GIS for Flood Inundation Mapping

**Prof. D Nagesh Kumar<sup>1</sup>**

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### Abstract

Modified Topographic Index ( $TI_m$ ) based on Digital Elevation Models (DEMs) was employed to delineate flood-prone areas in Mahanadi Basin, India.  $TI_m$  and flood inundation maps were compared to obtain, the threshold ( $\tau$ ) beyond which the area is assumed to be inundated by flood and exponent of the  $TI_m$ . Scale dependence was also investigated to evaluate the sensitiveness of spatial resolution of the DEMs. DEMs of five resolutions, namely, ASTER global, SRTM, GMTED2010 (30 arc-seconds), GMTED 2010 (15 arc-seconds) and GMTED 2010 (7.5 arc seconds) were used and ASTER global was preferred due to its low error compared to remaining. Flood frequency analysis was conducted to obtain relationship between flood-prone areas and flood magnitude. It was observed that (i) the exponent in the  $TI_m$  showed little variation, (ii)  $\tau$  is reduced with reducing spatial resolution of the DEM, and (iii) error is also reduced as the DEMs' resolution is reduced.

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Keynote Speaker-6

## Complexities in Urban Hydrological Modelling: Research Progress and Future Directions

**Prof. Subashisa Dutta<sup>1</sup>**

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### Abstract

Urban landscape is one of the sensitive and drastically changing ecosystems on the earth. Throughout our civilizations urban settlements were established proximate to rivers, plains, hills and valleys. The urban landscapes also experience the short time spatial scale modifications by anthropogenic activities. This creates the complex topographical structure in urban environment which influence each component of meteorological and hydrological processes in both local and regional scales. This also alters the both natural and manmade drainage patterns in urban and research community. The spatial variability of complex urban structures creates heterogeneity in precipitation, evaporation etc. The uncertainty in urban hydrological modeling and forecasting of floods due to the representation of real-world urban landscape in hydrological modeling is a challenging task to the both scientific. The first and far more challenging task is to predict and to represent the heterogeneous precipitation over urban landscape in hydrological modeling. The forcing of conventional measured precipitation to the model as a boundary condition is not sufficient. In general, for the urban hydrological applications requires the stringent rainfall data, in terms of both resolution and accuracy. It is identified that urban hydrological modeling applications needs order of 1 km and 1-5 min spatial-temporal resolution datasets. The weather RADAR derived rainfall has resolved this complexity by providing data at high spatial temporal resolutions. In recent, all 1D and 2D urban hydrological models are incorporated into RADAR rainfall data into their models. The major complexity is here that the retrieval of rainfall rates from radar reflectivity values, mostly in developing countries. A large number of researchers and scientist are marching towards this direction to increase in accuracy of rainfall rate extraction from weather radar reflectivity. The second most challenging task is to represent urban topography in the modeling application. It is widely accepted that the LiDAR DEM satisfies the all needs of urban hydrological modeling applications due to its spatial resolution, vertical accuracy and its ability to separate bare-earth from



surface features such as buildings and vegetation. However, the acquisition of LiDAR DEM is a challenging task to most of the developing countries due to budget and time constraints. It has increased the interest to scientists and researchers towards working on applicability of globally open-source DEMs in hydrological modeling than high resolution expensive products. The application of open-source DEMs in urban hydrological application yet to be explored. Along with these many questions has raised to scientific community, one of them is that Digital Surface Model (DSM) or Digital Terrain Model (DTM), which one is to be used in urban hydrological applications. We identified that the DSM is required to accurate prediction of flood inundation area, depths and its movement but it has also created artificial storage reservoirs in urban hydrological model. DTM is useful to identify the natural drainage patterns but it also overpredicted in flood inundation area and underpredicted in inundation depths. More research has to be done in this direction. The next challenging task is that representation of impervious area in urban hydrological model application, which is the most sensitive parameter in urban flood generation. Many researchers debate with Total Impervious Area or Effective Impervious Area and more research also has done towards this direction. This was useful when the Impervious area percentage incorporating in lumped or semi-distributed modeling frameworks such as SWMM or 1D surface-2D drainage coupled models or 2D surface-1D drainage at coarser spatial resolutions. In recent decades, the production of high spatial-temporal resolution datasets changed the urban hydrological modeling framework. The forcing of impervious fraction at each sub meter pixel level for each surface covering material will be helpful to improve the flood forecasting. We tried to resolve this complexity in our newly developed model which is capable to model at street level over a city scale by incorporating Impervious fraction at fine resolution pixels. The next complexity is to represent the real world natural or man-made drainage network in urban hydrological modeling framework. In most part of the world the drainage networks are designed way back in 1960s and in some parts the drainage networks are rapidly and unknowingly changing. The acquisition of these network data is a stringent task and also expensive. To resolve this complexity many researchers are incorporated drainage network in urban hydrological models by assuming that storm sewer system drains water away at the maximum design drainage capacity and no loss of capacity due to surcharge is considered. This assumption works fine when the drainages are functioning at its maximum design capacity, but in real the drainages are affected by blockage with sediment, plastic, bottles, weeds and other materials. The more research has to be done in this direction to estimate accurate draining capacity of surface runoff without focusing much on drain channel routing during high flood events. The major challenging task is the model itself. The existing 1D models and some of 2D models are much focused on storm sewer routing and less prioritized towards surface runoff. However, the modeling of surface runoff is more important during the high intensity of rainfall which produces the flash flood type of situation in urban settings. Due to the changes in the local landscapes alters the slopes of the urban streets and roads and also creates the depressions over a land, which are more prominent to creates floods than drainage overflow at average intensity of rainfalls. So, now-a-days the modeling of distributed surface runoff compartment in urban modeling is as important as drain routing compartment. In recent years, the advent of computational methods enabled the numerical modeling of both surface and drainage flow. In recent, many modeling approaches such as storm sewer flow routing in 1D and surface flow in 2D (1D/2D) coupling or complete 2D modeling or dual drainage modeling, loosely or tightly coupled techniques were evolved. However, the more research has to be done in this direction to develop the integrated model by incorporating all above-mentioned challenges or complexities to forecast floods within a short span and to manage the water in heterogeneous urban landscapes.

**Keywords:** *Urban Hydrological Modeling, Precipitation, Drainage, Topography.*

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Keynote Speaker-7

## **Geoinformatics Applications in Coastal and Ocean Engineering**

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### **Abstract**

Geoinformatics is the term coined for the combination of Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS). It has got ocean of applications in the areas of coastal and ocean engineering. All the forms of RS data namely optical, thermal and microwave are useful in way or the other for extracting the coastal and ocean parameters. Some of the major applications includes ocean colour monitoring,



impact of coastal structures on shoreline configuration and bathymetry, ICZMP, CZIS, SST, SSC, SLR, retrieval of waves, tides and other physical parameters of ocean. Few of these applications namely, estimation of SSC,

coastal vulnerability index, ICZMP executed in the department of applied mechanics and hydraulics are discussed in the present paper. The study carried out to identify vulnerable stretches of the Kasaragod coast in Kerala state, west coast of India, shows that 66.66% and 40.18% of the coast in the sub-districts of Kasargod and Hosdurga is under the high and very high vulnerability categories. The coastal LU/LC map implies that the coast is dominated by both built-up (32.21%) and agricultural lands (53%). The second study carried out for Devbagh beach along Karwar coast shows average shoreline change rate of -7.54 m/yr (EPR) and -5.57 m/yr (LRR) during pre-monsoon season and during post monsoon 0.34 m/yr (EPR) and -0.46 m/yr (LRR). Similarly, Ravindranath Tagore beach during pre-monsoon has average shoreline change rate of 0.004 m/yr (EPR) and 1.67 m/yr (LRR) and during post-monsoon -5.77 m/yr (EPR) and -6.55 m/yr (LRR). Another study related to undivided Dakshina Kannada coast confirms that the coast is maintaining its dynamic equilibrium. Overall geoinformatics tool helps to get the real time information regarding the coastal and ocean parameters.

**Keywords:** Remote Sensing, GIS, GPS, bathymetry and coastal vulnerability Index

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Keynote Speaker-8

## Impact of climate variability on Water Security of Tapi basin

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### Abstract

The impact of climate change has been significantly affected the human civilization across the globe. The rising global temperatures are expected to further raise the sea levels and change precipitation patterns and availability of water resources. The changing regional climates could alter forests, crop yields, water supplies and affect human health, animals, and other ecosystems. The deserts may expand into existing rangelands, and features of National Parks and Forests may permanently be altered. The water security implies affordable access to clean water for agricultural, industrial and household usage and is thus an important part of human security. It is estimated that estimated requirement of our countries water requirements to be around 1093 BCM for the year 2025 and 1447 BCM for the year 2050. With projected population growth of 1.4 billion by 2050, the total available water resources would barely match the total water requirement of the country. In 1951, the annual per capita availability of water was 5177 m<sup>3</sup>, which reduced to 1342 m<sup>3</sup> by 2000. The facts indicate that India is expected to become 'water stressed' by 2025 and 'water scarce' by 2050. The Tapi basin is situated in western central India between the latitudes 20° 5' N - 22° 3' N and longitudes 72° 38' E - 78° 17' E. The Tapi and Narmada Rivers are the only major rivers originating from the Indian Peninsula which drain into the Arabian Sea. The Tapi basin is elongated in shape with larger east-west extent than north-south. The Tapi River covers a total length of 724 km and drains around 65,145 km<sup>2</sup> area, which is nearly 2% of the total geographical area of India. The Tapi basin is demarcated into three basins, viz., Upper (from Multai to Hathnur dam), Middle (from Hathnur dam to Ukai dam), and Lower (from Ukai dam to the Arabian Sea) Tapi basins, encompassing respective geographical areas of 29,430 km<sup>2</sup>, 32,925 km<sup>2</sup> and 2790 km<sup>2</sup>. The Tapi basin exhibits wide range of physiographic differences, ranging from the high mountain ranges in its periphery and central alluvial river plains to the coastal-urban flood plains in the west. The detailed description of the study area is available in the study of Sharma and Patel (2021). The Tapi basin exhibits typical monsoonal climate with hot summers, mild winters and seasonal rainfall. The Tapi basin receives almost 85% of annual rainfall during the monsoon months from June to September, out of which almost 50% is received during the July and August months. The stream gauging stations in the Middle Tapi sub-basin, viz., Savkheda, Gidhade and Sarangkhedha stations, recorded considerable higher annual runoff (i.e., > 6000 Mm<sup>3</sup>), which predominantly contribute towards inflows into the Ukai reservoir (present gross storage capacity ≈ 7414.29 Mm<sup>3</sup>). On other hand, the annual runoff contribution from Girna, Bori and Panjhara Rivers to the Tapi River are reported to be very low (i.e., < 500 Mm<sup>3</sup>). Thus, a wide gap in the runoff characteristics of different



ivers across the Tapi basin is evidently observed. The rainfall-runoff behaviour across the Tapi basin is studied by analysing the characteristics of rainfall and streamflow duration curves for different sub-catchments. The change point and trends in annual runoff for fifteen stream gauging stations, for period 1973-2013, are investigated using Pettit's and Mann-Whitney U tests; and MMK, SR and Sen's slope estimator tests respectively. The changes in annual runoff is attributed to possible climate variability and/or anthropogenic activities and relative contribution of aforesaid factors are quantified using two statistical approaches, viz., climate elasticity method and double mass curve technique. The trends in five extreme streamflow indices, describing absolute and threshold-based high flows and frequency of low flows, are investigated. The detailed analyses are available elsewhere (Priyank et al., 2019).

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Keynote Speaker-9

### **Application of simplified routing methods for hydrometric data-based real-time flood forecasting**

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#### **Abstract**

River routing is one of the hydrological component processes that can be simulated accurately in comparison with the simulation of the runoff process using the causative rainfall. This could be attributed to the confinement of flood flow within the channel section which is possible to be monitored relatively easily, contrary to the runoff generation process caused by spatially and temporally distributed rainfall process. Consequently, the uncertainties associated with flood movement process in rivers are less in comparison with the rainfall-runoff process. Therefore, real-time flood forecasting based only on the channel routing process is expected to be more reliable than that based on the rainfall-based forecasting, though at the cost estimating forecast with short lead-time. The reliability of river forecasting can be enhanced using models developed based on equations governing the flow process in channels rather than using empirical or black-box models. In this regard the simplified routing models can be considered more attractive due to their applicability with limited data, especially the channel geometry data, in comparison with the applicability of the full Saint-Venant equations. In hydrological literature, the term "hydrometric data-based forecasting" is interpreted in two forms: 1) interpretation from the perspective of using only the hydrometric data without involving the precipitation data, like the case of employing only the channel routing methods for forecasting based on hydraulic or hydrological models, and 2) interpretation from the perspective of employing data-based models for linking input (stream gauge or discharge) and output (outflow gauge or discharge) using empirical models such as the ANN models. Based on ANN models, one can also use evolving rainfall event for flood forecasting in river reaches. Such a consideration is not accommodated using the first form of the model. Therefore, the term "hydrometric data-based forecasting" is used in the context of the first interpretation only. The process of estimating the expected stages or flows and their time sequences at selected vulnerable points along the river course during floods is called "Real-Time Flood Forecasting". Real-time flood forecasting systems are formulated for issuing flood warning in real-time in order to prepare the evacuation plan for safe-guarding the lives of humans and livestock, and movable properties of the people during floods. Experiences have shown that the loss of human life and property can be reduced to a considerable extent by giving reliable advance information about the expected floods. The effectiveness of real-time flood forecasting system in reducing flood damages would depend upon how accurately the estimation of the yet to arrive stages or flows of flood and its time sequence at selected points along the river could be forecasted during the propagation of the evolving causative input. Therefore, there is a need for methods or models capable of efficiently forecasting water levels or discharges at desired locations along rivers. Efficient forecasting requires that the structure of the model should be simple, easy to be understood and handled by flood control engineer and it should not have excessive input requirements, but at the same time the forecast must be accurate enough to serve the intended purpose. Typically, the flood forecasting models make possible to simulate the response of the system to a given input at a given location under the existing system conditions. The forecasting models generally operate on calibration (off-line) and operation (on-line) modes. The calibration mode tries to produce the response of the system for the past recorded precipitation or upstream flow input. This calibrated response is compared with the recorded response at the point of forecasting interest to check the matching of these two responses. If the matching is done satisfactorily the model structure or the model parameters need not be changed, otherwise the model parameters



are to be modified till the matching is done satisfactorily. Once the structure of the model frame work is finalized in the calibration mode, the model can be adopted for operational mode of using it for the forecasting purposes. While the basic structure of the model is not changed in the operational mode, the parameters are changed considering the current catchment conditions due to the evolving input. To effectively accounting this evolving scenario, forecasting models have two components: 1) deterministic flow component and 2) stochastic flow component. The deterministic flow component is determined by the identified hydrologic or hydraulic mode; whereas, the stochastic flow component is determined based on the residual forecast error series of the difference between the forecasted flow of a specified lead-time and the corresponding observed flow. While forecast error reflects both the model error, due to the inability of the model used for forecasting to correctly reproduce the flow process and the observational error while measuring the flow. Hydrodynamic principle-based models such as MIKE11 and HEC-RAS models can be used as deterministic flow component models, but at the cost of using hydrometric and morphometric data at close temporal and spatial resolutions. These models are not suitable to serve the purpose of flood routing in rivers where detailed topographical surveys of channel cross-sections and roughness at close intervals are not available. Alternatively, implementing a channel routing method developed only based on normal rating curves and the cross-sectional details available at the end-sections of the reach, corresponding to where forecast is made and forecast is required, simplifies the forecasting problem of the operational flood management. Under the above requirement, the application of a physically based simplified flood routing method as a component model of a hydrometric data-based deterministic forecasting model along with a simple autoregressive forecast error estimation model may be found useful for real-time flood forecasting applications. Therefore, it is considered worthwhile to examine the suitability of a simplified physically based method like the variable parameter McCarthy-Muskingum method (VPMM) studied herein as an example model application for real-time forecasting at a river gauging station. The study focuses mainly to verify the suitability of the VPMM method as a component model of a hydrometric data-based forecasting model in conjunction with a two-parameter linear autoregressive forecast error estimation model for real-time flood forecasting applications in natural river channels. The river reach of 15 km length between Pierantonio and Ponte Felcino, the upstream and downstream gauging stations, respectively, of the Tiber river in Central Italy is considered for the application of this model for real-time forecasting at the Ponte Felcino station, knowing the evolving flood at the Pierantonio station.

**Keywords:** *hydrometric data-based, simplified routing methods, real-time flood forecasting, VPMM.*

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Keynote Speaker-10

## **Detecting Partial Blockages in a Pipeline by Modified MOC-Reconstruction**

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### **Abstract**

Blockage detection using transients has emerged as a promising technique as it requires the measurements only at one location. The current research proposes a modified MOC reconstruction technique suitable for detecting multiple partial discrete and extended blockages in a pipeline. The current study's novelties over other similar methods are: (1) The MOC Reconstruction method is derived for discrete blockages; (2) The same technique can be comfortably applied for both discrete and extended blockages with due consideration of pipe friction. (3) The method is easily extendable for viscoelastic conduits. The paper discusses the significance of the inclusion of viscoelasticity in the model. It is proposed that evaluating the steady-state head in the pipe can determine the discrete blockage parameters, and flow area reconstruction can be used to estimate the multiple extended blockages. The pipe is discretized into several finite cells, and characteristics equations are derived for inverse computation of steady-state flow parameters. Singularity or defect is assumed at the interface of the cells. Adoption of the novel grid arrangement enables to model the discrete and extended blockages. Friction factor need not be known a priori in the case of detection of discrete blockages. Knowledge of upstream reservoir boundary conditions is not required. The technique uses a short-duration signal. The blockage prediction is more accurate as compared to the techniques that use multiple cycles of the signal, as short-duration signal is used. The MOC characteristics equations for inverse computation are derived for elastic and viscoelastic pipes with steady friction factors. The methodology is validated against various numerical and experimental transient data available



in the literature. The validations show excellent agreement between the numerical and experimental results. A sensitivity analysis indicates the influence of system parameters on the detection results.

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Keynote Speaker-11

## **Sustainable Water Management through Promotion of Voluntary Afforestation**

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### **Abstract**

The role of vegetation in general & forests in particular in ensuring sustainable water management is well established. Nevertheless, over the past several decades, forest cover is continuously decreasing in many parts of the world, mainly due to deforestation. Simultaneously, there is also a steady increase in the concentration of greenhouse gases (GHGs) in general and Carbon Dioxide in particular. Main causes for this phenomenon are the emissions from fossil fuel combustion, aerosol generation, cement manufacturing. Things have reached such an alarming level wherein the Himalayan nation of Bhutan is the only carbon negative country in the world! Even some of the best management practices (BMPs) adopted in Arctic Norway, Alpine Switzerland, Mediterranean Israel and Tropical Singapore have not transformed them into either carbon neutral or carbon negative nations so far. Based on the Indian traditional knowledge (ITK) on precipitation constellations, an attempt is made in this study to promote voluntary afforestation and thereby increase the awareness aimed at achieving sustainable water management as well as effectively combating climate change.

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Keynote Speaker-12

## **Evolution of a Navigational Channel in Tapi Estuary through Model Studies**

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### **Abstract**

Planning of port development projects in a deltaic estuary is a tricky job and it becomes highly complex in the case of determining potential sedimentation and erosion rates in dredged channels. But accurate dredging projections are crucial for economic feasibility analysis in addition to assessing the impact of new structures interfering with the natural processes on the adjacent shoreline and the morphology of the system. Silt mitigation measures are necessary to reduce the siltation in the navigational channels. In this study we consider a range of approaches for evaluating sediment transport for evolving a new navigation channel and necessary silt mitigation measures for harbour planning, and present detailed case from West coast of India. A depth-averaged numerical model for the erosion, sedimentation and transport of cohesive sediment is applied to the estuary. This study is based on the numerical simulation of the mean river discharge and the tidal forcing. The hydrodynamic models were calibrated against field measurements corresponding to the period in which the experimental data were registered. The site described is representative of a very complex coastal environment. The Tapi Estuary in Hazira, is a unique dynamic estuary in Gulf of Kambhat on the West coast of India with large tidal range, non-perennial river discharge and high sediment loads of sand, silt and clay presenting challenges for navigation and dredging. The approaches include preliminary site investigations and data collection, basic sediment transport theory, and a range of numerical modeling techniques that can be applied to determine sediment erosion, transport and deposition. Further, once the navigational channel was operational new developments and some environmental aspects which were induced with the expansion of the project involving reclamation was also studied in detail and the challenges faced during the execution of the project and evolution of the navigational channel is described in this lecture. Presently the project authorities are planning to develop a port city within the estuary for which model studies to assess the impact on flow conditions and sedimentation aspects is in progress and will be touched upon



during the presentation which would help the port planners and modelers in systematic approach while carrying out such projects.

**Keywords:** *Modeling, Sediment Transport, Tidal Motion, Currents, Tapi Estuary.*

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Keynote Speaker-13

## **Flood Management in Tropical Countries with Special Reference to Medium and Small Catchments**

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### **Abstract**

Flood is a high stage in a river which leads to inundation of flood plain and over topping of flood embankments. This results in the loss of life and properties of millions of human being, and other living creatures. Hence there is a need for relatively accurate forecast of arrival of the flood with sufficient lead time, so that the management of flood disaster becomes easier and effective. The process of flood flow is basically uncertain and unpredictable owing to its complex and non-linear dependency on a variety of meteorological and topographic parameters. This process is more aggravated in medium and small catchments of tropical countries. Also, in the real world situation there are numerous external factors, which affect the decision making process. In certain critical conditions, the river basin managers take a decision based on intuition and experience, which cannot be justified with facts and figures. Therefore, it is realized that complex real-world problems require intelligent systems that combine knowledge, techniques, and methodologies from various sources. These intelligent systems are expected to possess human-like expertise within a specific domain, adapt themselves and learn to do better in changing environments, and explain how they make decisions or take actions. Attempt has been made in this presentation to highlight and focus the methods and techniques of flood management in small and medium catchments of tropical countries. The statistical methods, mathematical models, numerical models, physical models and artificial intelligence techniques are presented. The methods of performance analysis of various models are mentioned alongwith the future research avenues. Relative importance and performance are also discussed to make the deliberation effective.

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Keynote Speaker-14

## **An Overview of Industrial Water Supply Systems**

**Prof. Sunil Kr Sarangi**

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### **Abstract**

Fresh water is an important consumable of industry – power plants, steel, fertiliser, petroleum refining & petrochemicals, paper & pulp, food & beverages, semi-conductors, electricity generation being the single most important industry in terms of volume of water consumed. Because fresh water is scarce, most industries recycle their waste water, employing large and complex equipment. Processing of fresh or recycled water can be grouped under several broad heads: (1) raw water, (2) boiler feed water, (3) cooling tower water, (4) wastewater, (5) water as a heat transfer medium, (6) water for food and beverages, and (6) ultra pure water used in semiconductor manufacturing. We shall review the role of water use in various industrial processes and the technologies employed for purifying and processing it. Water treatment plants are complex, and involve movement of water



among different equipment. Delivery of treated water to different stations in a large factory involves long pipelines, de-aeration devices, and more. The water supply will engineer has to ensure delivery of the right volume of water with right purity, at the desired temperature and the desired pressure level at every station. To do this, he will use pumps, filters, pipelines, valves, stream splitters and fluid mixers. He has to ensure that all this is done using the minimum energy and minimum loss of the valuable commodity - fresh water, whether surface water, ground water or a combination of both sources. We will discuss the principles and design approaches for engineering the water supply system of a large industry. While most industries are set up near sources of fresh water - lakes, rivers, and proven ground sources, sometimes geographical and economic constraints preclude such possibilities. The industry must use sea water, either in the native saline condition, or as de-salinated sweet water. We will touch upon some current technologies.

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Keynote Speaker-15

### **Shoreline protection for Odisha Coast with a case study on Geo-tube Embankment at Pentha in Kendrapara District**

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#### **Abstract**

India has a vast coastline of about 8158 Km. Odisha has an extensive and diverse shoreline of about 480kms. Due to climate change, very often we find natural disasters and critical events, which badly affect the coastal areas. Due to climate change, there have been significant changes in rainfall pattern and rainy days. In 2004, Tamilnadu faced Tsunami. Odisha is of no exception in facing severe cyclones. In 1999, Odisha faced Super cyclone followed by PHILIN, HUDHUD, TITLI, FANI, BULBUL etc. Due to such regular disasters, besides coastal communities, adjoining areas are always at risk. So, there has been extensive study at all corners for shoreline protection measures to reduce risk from coastal hazards. A study reveals that 36.80% length of coastline (176.70 Km) of Odisha accounts for erosion. Out of these, nearly 8.2% length (39.33 Km) are undergoing high erosion. The major reason behind this erosion is regular storm surge and flood in the coastal districts of the State. After the severity of 1999 Super-cyclone in the coastal zone of Odisha, many studies have been undertaken by various reputed organisations to assess the possible storm surge along the coastline during such critical events. Study revealed that the coastline of the State may experience the highest surge in the country ranging between 4.6 to 10.6 metre. The studies have become helpful in designing a suitable protection measure for various stretches to be resilient. The occurrence of cyclones is increasing in frequency. As such, it is quite essential for the State to strengthen the saline embankments along the shoreline to be cyclone resilient. The stretches of the coastline experiencing high rate of erosion have been identified and it is pertinent to protect such critical stretches. The coastline of Kendrapara District is experiencing a very high rate of erosion. The erosion at Pentha of Rajnagar Block in Kendrapara District was found to be extremely severe. During 2013-2016, a Geo-tube Embankment has been constructed at Pentha, which has been successful to arrest the severe rate of erosion in the location. There are 5 nos of eroding beaches of tourism importance at Talsari, Pentha, Siali, Puri and Ramayapatna which are to be protected by technological intervention. Odisha has already gained experience of construction of cyclone resilient saline embankment of nearly 52 Km of length in various stretches, which have successfully protected the localities from severe cyclones during the past 6 years. The other stretches of saline embankments need to be strengthened similarly. In this piece of presentation, it shall be explained on the status of the coastline of Odisha, various studies assessing the possible storm surges along the coastline under various climate change scenario, experience of construction of Geo-tube embankment at Pentha in Kendrapara District, possible technological intervention in protection of 5 nos of eroding beaches of tourism importance at Talsari, Pentha, Siali, Puri and Ramayapatna as well as strengthening of nearly 360 km stretches of saline embankments to be cyclone resilient in order to protect people during a critical cyclonic event.

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Keynote Speaker-16

## Modelling of environmental flow requirements using hydrological and habitation models

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### Abstract

Anthropogenic activities in the Krishna River have altered its flow regime and affected the ecosystems in the river. It is, hence, essential to maintain an optimum Environmental Flow (EF) in the river to recover from its deteriorated ecosystem. The study estimated the Environment Flow Requirement (EFR) and the Hydrological Alteration (HA) (Flow changes) that take place on the Krishna River at five dam sites. Pre and post construction impact flow data are collected at five gauge stations which are located downstream of these five dams. The flow data which are impacted by climate variability are removed and the focus was on the impact of human activities. These EFRs are estimated using statistical relationships between the Krishna River flow regime and ecological indicator with the help of the Global Environmental Flow Calculator (GEFC). HA is used to analyse how the recommended EFRs are different in the post-impact period (after the dam construction). Hydraulic indicators like water depth and velocity are determined by importing estimated EF values into a Hydrologic Engineering Centre's - River Analysis System (HEC-RAS) model. The habitation analysis is carried out to check whether the hydraulic indicators are providing an acceptable habitation for aquatic species in the study area. The results from HA analysis showed that the required EFRs in the Krishna River were not maintained for almost 43% of the time in the post impact period. The hydraulic analysis showed that recommended EFR is providing velocity in the range of 0.12 m/s to 1.08 m/s and water depth in the range of 0.23 m to 3.16 m throughout the basin. Habitation analysis was carried out and it is observed that calculated EF values through GEFC approach is providing condition for excellent habitation under the dams of Srisaïlam and Nagarjuna Sagar. Good habitation conditions are seen under Narayanapur, Ujjani, and PD Jurala dams.

**Key Words:** *Environmental Flow Requirements (EFR): Global Environmental, Flow Calculator (GEFC): Hydrological Alteration: Krishna river.*

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Keynote Speaker-17

## Recipe for Achieving Water Security & Sustainable Development in India

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### Abstract

Projections of water demand, according to the Ministry of Water Resources, indicate that India will be able to meet her water requirements until the year 2050 through integrated water resources management. At the outset, this prediction appears to be very satisfactory, however, the ground reality is that even currently also majority of the basins are exhibiting hydrological stresses that are posing hoard of problems to the stakeholders. Therefore, there is an urgent need for making fresh assessments to capture the spatial and temporal variability of both, availability of water resources as well as composite demands imposed by the society. It is quite likely that two crucial demands i.e., environmental flow demand and the demand on account of a range of local and national level programs that are being implemented or are planned were not factored in while making the assessment. The spatial and temporal capture of the water resource availability is a very exhaustive exercise because of the inherent natural variability as well as due the development of water resources in the form of small, medium and large scale diversion and storage projects. Some of these projects may entail consumptive use of water whereas the others



may have non-consumptive use. However, in either case they shall have some impact on the hydrology of the drainage area. For evaluating such implications, the distributed hydrological models are excellent tools to play the role of generating all the desired elaborate information in time and space through simulation process. It has already been realized and accepted through the National Water Policy that we need to formulate river basin management plans and the first such initiative has already been taken up in the formulation of Ganga River Basin Management Plan (GRBMP). However, this covers only the aspect of present management of the water resources. The other aspect that is becoming more relevant is the climate change implications to the water resources. Throughout the World countries are engaged in formulating policies to cope with the implications of climate change to the water resources and agriculture. Impacts of climate change on the water resources of various river basins have been evaluated by using the SWAT (Soil and Water Assessment Tool), a distributed hydrological model under the present and the future conditions. Projections made by the Regional Climate Models (RCMs) on the future weather conditions have been used as input in the SWAT model. Implications on account of the changing weather conditions have been evaluated in terms of changes from the present levels. Extremes in terms of floods and droughts have also been evaluated on temporal as well as spatial scales of the landmass of the river basins. Frameworks are required to be formulated for managing such huge information bases as well as facilitating the implementation of IWRM principles. These shall also be useful for generating plausible scenarios for adaptation to climate change impacts.

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Keynote Speaker-18

## Temporal Networks-Based Approach for Nonstationary Hydroclimatic Modelling

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### Abstract

Lack of stationarity in most of the hydroclimatic variables is no longer a topic of debate rather a reality. It may be hypothesized that alternative methodologies are needed to deal with such non-stationarity and to improve the skill of hydroclimatic modelling/prediction. We propose the concept of *temporal networks* in hydroclimatic modeling as a potential solution to this problem. This talk is divided in two broad parts: first, the long-lead seasonal prediction of Indian Summer Monsoon Rainfall (ISMR) is considered. We propose that this is due to the temporal evolution of association/linkage (inherent concept of temporal networks) with various factors and climatic indices across the globe, such as El Niño-Southern Oscillation (ENSO), Equatorial Indian Ocean Oscillation (EQUINOO), Atlantic Multidecadal Oscillation (AMO), North Atlantic Oscillation (NAO), Pacific Decadal Oscillation (PDO) etc. In the second part, complex association among different hydroclimatic variables and streamflow is considered as an illustrative problem. Evolution of temporal networks over time, obtained through Graphical Modeling (GM), depicts the changes in the model inputs as well as model parameters over time. The proposed concept indicates that the time interval after which the model needs to be updated/recalibrated, referred to as Optimum Recurrence Interval (ORI), is problem specific and is optimized to achieve the best model performance. The proposed concept not only depicts a notable change in the potential predictors for the high and low flow months, but also establishes the different extent of temporal variability for different months, and hence the ORI of model recalibration. As compared to its time-invariant counterpart, the temporal networks based approach shows higher efficacy in capturing the extreme flow events due to its inherent time-varying characteristics. We recommend the concept of temporal networks to be promising in the context of climate change to capture the time-varying association. In general, the concept can be applied to other hydroclimatic variables where a time-varying association is expected due to various reasons including the impacts of climate change.

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Keynote Speaker-19

## Coastal Vulnerability in a Changing Climate

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### Abstract

IPCC has already established the fact that ocean heat content, sea level, wave height, and ocean extreme events are on the rise. The intensity and frequency of the cyclonic events are increasing emphasizing the need for better representation of processes and physics in the predicting tools. Wind, the major forcing represented by wind drag coefficient, should be evaluated using Enhanced Wave Boundary Layer Model (WBLM) to accurately predict storm surge in real-time. The improved wind drag (IWD) method developed by Shankar and Behera (2021) accurately computes wind drag coefficient for super cyclonic wind speed up to 90 m/s. It is also necessary to consider pre-existing wind field for accurate storm-wave prediction. The intensified cyclones in the changing climate would lead to stronger surge along the coast leading to greater inundation and damage to the coastal regions. Thus, coastal inundation maps have been developed for various RCP scenarios to assist in disaster preparedness and management of mitigation measures. In additions to the short-term extreme events, long-term processes like sea level rise (SLR) is a major concern for the coastal community. The SLR accompanied by ground settlement leads to sea water intrusion on to low laying areas and estuaries. This will substantially affect the coastal bio-geo-systems. SLR also aggravates the saline water intrusion into the coastal aquifers and contaminates the ground water. The ocean wave climate, driven by the wind, have shown substantial changes in the future scenarios (Choudhury et al. 2019). The altered wave height, period and directions can drive the change in coastal processes and profiles. Chowdhury et al. (2020) have shown the future wave-climate driven longshore sediment transport along the Indian coast and prepared coastal stability maps for practical references. The coastal infrastructures are equally vulnerable under the frequent extreme wave attacks and need appropriate guidelines for rehabilitation and new constructions. Considering the rising sea level and extreme focused waves, Moideen and Behera (2020) developed empirical formulations to compute the modified forces for coastal deck structures under non-breaking and breaking extreme waves. These are very useful for practical engineers without going for some high end computational or expensive experimental investigations.

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Keynote Speaker-20

## Analysis of Coastal Erosion Problems in the vicinity of Netravathi-Gurpur River Estuary, West Coast of India – A Modelling Approach

**Prof. Subba Rao**

Professor, Dept. Of water Resources and Ocean Engineering,

National Institute of Technology Karnataka Surathkal

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### Abstract

The coastal problems such as beach erosion, inlet stabilization etc. is commonly found in all maritime countries. However, they are unique and site specific due to variety of reasons. Various coastal strategies are adopted to protect life and property against storms, high waves and to combat erosion and/or to create artificial beaches and to preserve the natural environment. These include hard measures and soft options or combination of different measures. Different solutions are adopted in different countries depending upon their individual problems. These vary from beach nourishment and sand filled geotextile tubes to groins and offshore breakwaters. No single set of regulations, or single land use management philosophy, is appropriate for all coastal situations or settings. The diversity of the coasts requires consideration of a variety of solutions while addressing the problems in a particular area. Severe coastal erosion takes place during the monsoons along the Southern Karnataka coast at Ullal. This stretch of land is a part of Mangalore city of Dakshina Kannada (D.K.) district where Netravathi and Gurupur rivers join to form a common estuary before emptying into Arabian Sea. Most of the changes on the D.K. coast are of a cyclic nature maintaining a long term dynamic equilibrium. The site of erosion is a barrier spit over a length of 1.4 km connected to main land at one end. The other end of this spit was free to migrate as a part of



changes in shoreline around the mouth of River Netravathi. Similarly, in the north, known as Bengre spit exists running parallel to the mainland. Gurupur River also joins this mouth running from north adjacent to Bengre Spit. The migrations of both the spits have been contained with the help of breakwaters since 1994 and the navigability of the fishing vessels have been improved. Subsequently wide scale erosion and accretion have been reported in Ullal and Bengre respectively. Predominant deep water wave direction changes seasonally and these waves become almost parallel to coast due to refraction as they near the shoreline (KREC Study Team, 1994). The maximum wave height of 6.5m was observed in deep waters, maximum significant wave height ( $H_s$ ) is about 3.44 m with the average zero-crossing period of 10.4 sec. The largest single wave recorded is about 5.4 m and typical SW monsoon waves are of height about 4 m. Tides are mixed with a strong semidiurnal component with a mean tidal range of 1.2 m. and spring tidal range of 1.8 m. The ocean currents along the D.K. coast also change seasonally with velocities ranging from 0.11 to 0.41 m/sec. Such natural changes occurring near the river mouth assumes importance when these areas are encroached by population. Solutions including rubble mound revetments and seawalls have not been useful for shore protection. Hence, there was a need for detailed investigations in order to arrive at critical forcing factors causing beach erosion at Ullal, design a permanent, effective and economical solution to save the coastline. The sediments brought by the rivers are primarily suspended load which consists of the clays and the silts and this is dispersed by the ocean currents. The sand fractions are deposited in the beaches adjacent to the river mouths. Beaches after being subjected to erosional phase during monsoon season were found to regain their profiles later. But there is slow net erosion in the beaches of Ullal over the years. In order to fulfil the above objectives, a set of methodologies have been formulated and executed in different seasons to arrive at a complete coastal protection plan for the study area. It includes collection of existing data, delimiting the study area, in-situ data collection regarding various ocean parameters using state-of-art equipments such as wave/tide gauges, current meters, echo sounders, GPS, ADCP etc., data analysis, numerical modelling of the processes and finally to select a suitable protection measure and suggestions for implementation. The various modules of the software package MIKE 21 developed by the Danish Hydraulic Institute (DHI) have been used for modelling the hydrodynamics, waves and sediment transport phenomena in the study area. The forcing factors of erosion at Ullal have been recognized as waves, tides, currents, discharge of river water, sediment movement and the complex interplay of the circulation patterns. It has been inferred from the studies that during monsoon season net sediment movement is towards south, during post-monsoon season it is towards North and during pre-monsoon season it is towards south. The paths traced by sediments as per STM analysis are in good agreement with model results. The sediment budget of the study area on a short time scale indicates a small erosion of Ullal beach while the beaches in Bengre are stable. To contain the erosion at Ullal, three different structures such as simple groin system, T-groin and submerged reef were considered for analysis. From the modelling results, a single T-groin at the tip of Ullal breakwater in combination with a series of submerged reefs all along the eroding coast has been found to be most effective solution.

**Keywords:** Waves, tides, currents, hydrodynamics, erosion, accretion, spectral analysis.

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Keynote Speaker-21

## Sedimentation Rate Behavior Analysis using Chaos Theory

**Prof. V. Jothiprakash<sup>1</sup>**

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### Abstract

The hydrological process, sedimentation rate is usually complex and shows variability in space and time due to their governing physical parameters. The variability in sedimentation rate in different rivers depends mainly upon the discharge it carries throughout the year and soil erosion zone of the basin. Over the past, the common methods employed for modeling sediment process are mathematical models and classic equations starting from, linear equations, multiple linear regression, linear stochastic models, artificial neural network etc. All these models require time series data and a specified number of inputs to predict the output, the sedimentation rate. Nevertheless, to determine the number of parameters to describe the system was tedious and time-consuming. Chaos theory played a very effective role as it helps in determining the dominant governing variable required to

describe the system. This study examines the dynamics of the sedimentation rate variability across several large river basins in India from a non-linear dynamics perspective. To determine the variability of sedimentation rate, a non-linear dimensionality based false nearest neighbour (FNN) method is employed. From the FNN analysis, the optimum embedding dimension is determined. The variability of sedimentation at different season is also investigated by comparing the full-year analysis with monsoon period (June to September) analysis result to know the spatial and temporal variability of sedimentation rate. The results indicate that all the stations showed chaotic behavior with dimensionality of ranging from as low as 4 to as high as 14 considering full-year and monsoon period. A sample FNN result of west flowing river Tapi is shown in Fig. 1. From the Fig. 1. It can be seen that the percentage false nearest neighbour starts with 100% at low dimension and goes on decreasing with increase in dimension and become very low at higher dimensions.

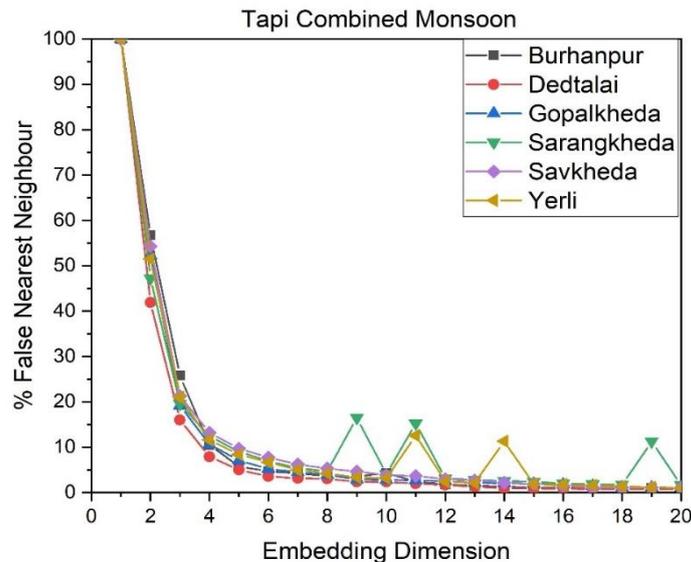


Fig. 1 FNN results of measured sedimentation rate in Tapi basin gauging stations

An attempt is also made to compare the complexity and variability between sediment rate and streamflow on the same CWC station considered for sedimentation rate variability study. From the results, it was observed that the sedimentation rate showed more variability across spatial scale than streamflow due to the involvement of various physical parameters during the full year and monsoon period.

**Keywords:** Spatial Sedimentation Rate Variability, Non-Linear Dynamics, False Nearest Neighbour, Phase Space Reconstruction, Embedding Dimension.

Keynote Speaker-22

## Intelligent IoT for Water Resource Management

**Dr. D P Acharya**

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### Abstract

The current environment is moving towards Internet of things (IoT) era and continuously growing day by day for smart factories, security improvement for cargo system, smart hospitals, smart cities, smart grids, precision agriculture, precision medicine and a host of others which can be controlled by our smartphone, video transmission with high efficiency using fourth generation of Global System for Mobile Communication. The use of 4th generation cellular network provides us better communication with remote system form anywhere in the world. Therefore, that can provide better control over organizations with remote monitoring whenever required we can



also take different actions accordingly which is possible by enabling our smartphone or PC. Further the enormous data acquired through such a system can be intelligently analyzed by use of machine learning algorithms like neural network, deep learning which can extract meaningful information. This information will be key in decision making process. Given this capability of intelligent IoT, cost effective solutions can be developed for collecting real time information of rivers. Rivers are lifeline of any country. They provide drinking water, water for irrigation. They also cause devastation like floods as one of the most common form of natural disasters in the world. A poor management of river water potentially causes draughts. Water gets polluted by human and industrial use. An effective monitoring can trigger remedial measures for purification to maintain water quality. An IoT based system has the capability to play a major role in monitoring the water quality. There is a critical requirement for development and installation of enhanced flood forecasting systems in various commonly flooding regions of the world. The intelligent IoT based system enables various types of electronic gages to be deployed at remote locations, wherever mobile network is available. Acquisition of hydrological data occurs at user defined intervals of time, and is uploaded to a database, through the internet. Information acquired into the database can then be easily accessed from anywhere, used for analysis, and running flood forecasting simulation models. A good management of water flow in a river can prevent floods and draughts too.

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Keynote Speaker-23

## **UTTARAKHAND FLOOD – 2021: REASONS AND LESSONS TO LEARN**

**Er. Ashutosh Dash**

*CE cum Additional Secretray Deptt. of Water Resources, Govt. of Odisha*

### **Abstract**

In Uttarakhand's Chamoli district, on dated xx, flash floods in the Alakananda river system wrecked widespread destruction. The deluge nearly swept away the Rishiganga and Tapovan-Vishnugad hydropower projects and affected several places including joshiMath, Raini and Ringi. In fact, a part of the Nanda Devi glacier broke off in Uttarakhand's Chamoli district, leading to massive floods and multiple casualties. The Scientist community is divided in arriving at any convergent opinion regarding the exact reason behind this mishap. This avalanche of mud and water was triggered when a chunk of the Nanda Devi glacier near Joshimath broke off, falling into the Dhauliganga river below, causing the tragedy. This is not the first time this area has been devastated by landslides and floods. In this century alone, there have been similar incidents in 2004, 2005, and, most devastatingly, in 2013, when a cloudburst caused flash floods around the pilgrimage site of Kedarnath, killing over 5,700 people during the annual Char Dham yatra. An interesting fact worth observing is that regarding this incident, The Scientist community is divided in arriving at any convergent opinion regarding the exact reason behind this mishap. The reasons attributed by them span across a wide horizon starting from cloudburst leading to a massive land slide, outburst of a glacial lake which had formed underneath the glacier which is called GLOF, (Glacial Lake Outburst Floods), Glacier melting due to temperature rise and the like. The paper attempts to capture the tragic incident, analyze various viewpoints for reasoning the cause of the massive flood and concludes by exploring possible lessons to learn and by scoping the necessity for further research in this regard and argues to adopt precautionary principle for further developments in this area.



Keynote Speaker-24

## Status and Management of Groundwater in India

**Prof. Rajib Kumar Bhattacharjya<sup>1</sup>**

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### Abstract

The groundwater use in India has increased by 500% over the past fifty years due to extensive irrigation and municipal uses. An estimation carried out by the Central Groundwater Board of India shows that fifteen percent of the administrative blocks in India extract more water than is replenished. As a result of the unplanned groundwater exploitation, the water table has depleted in many parts of India. According to a NITI Aayog report, 21 major cities, including Delhi in India, will run out of groundwater. Another study conducted by the National Geophysical Research Institute shows that the groundwater levels in Delhi are depleting at an alarming rate of 10 cm per year. The data recorded at the monitoring wells of the Central Groundwater Board also shows that the groundwater table is depleting at an alarming rate in many cities in India. Moreover, the groundwater is also depleting due to the change in the land use-land cover of an area. A study carried out by UNDP reveals that the state of Uttarakhand, which is considered a water reservoir for the Indian subcontinent, has faced drought in 10 out of 13 districts. Several springs of the state have been dried out gradually due to the change in land use land cover of the state. Similar situations have also been observed in some other hilly areas of the country, e.g., Meghalaya, Mizoram, Sikkim, etc. As such, sustainable management policies have to be adopted to arrest the further degradation of this treasured resource. This paper discusses the present status of groundwater in India and some standard management policies that can improve the situation. The estimation of groundwater's spatial and temporal distribution using GRACE and GLDAS data has also been explored.

**Keywords:** Groundwater; GRACE, GLDAS, Sustainable Management, Depletion

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**DAY 1**  
**26<sup>th</sup> March 2021 (Friday)**

**Invited Speaker -1**

**Prof. Sameh Kantoush, Disaster Prevention Research Institute (DPRI), Kyoto University,  
Japan**

**Time: 11:45 am to 12:25 pm**

**Topic: Integrated Reservoir Sediment Management at the River Basin for Sustainable  
Water Resources Management**

**Invited Speaker -2**

**Dr. Sebastien Proust, Researcher, INRAE, Lyon, France**

**Time: 12:45 am to 1:25 pm**

**Topic: Large-Scale Structures in Transversally Sheared Open Channel Flows**

**FIRST TECHNICAL SESSION**

**PARALLEL SESSION 1/SERVER 1**

**Time: 02:10 PM to 05:20 PM**

**Theme: Coastal and Ocean Engineering**

KEY NOTE SPEAKER	TOPIC
Prof. M. C. Deo, IIT Bombay	Future Shoreline Erosion and Sea Level Rise at Some of the Indian Coastal Locations

**PARALLEL SESSION PRESENTATIONS**

**Session Chairpersons: Dr. R. G. Patil, CWPRS Pune, Prof. Rutuja Chavan, MANIT Bhopal**

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	071	Dayananda Shetty K, Vijayanand.Gurudev, Dwarakish.G.S.	Factors affecting the Vessel Turnaround time in a Seaport
2.	077	G. Lenin Reddy, M. G. Muni Reddy, T. V. Ramana Murthy, M. L. Narasimham	Diffraction Studies Pertaining To Functional Design of Breakwaters- A case Study of Gangavaram Port, East Coast of India

3.	083	Surakshitha, Manu, Subba Rao	Innovative soft option of coastal protection by floating seaweed farm - a review
4.	112	Aseem V, Dwarakish G S	Study of sediment behaviour along the Mangalore coast through granulometric studies
5.	114	Anjita N A, Makhdumi W and Dwarakish G S	Study of shoreline change along Kasaragod district in Kerala, West Coast of India
6.	129	Ms. Soniya Xaviour, Dr. J. D. Agrawal	To ascertain the effect of modelling parameters on wave transformation models
7.	131	Mr. Ishfakh M Shafeekh, Mr. M. Phani Kumar	Mathematical modelling to ascertain the effect of Groyne field on beach fill stability
8.	383	Sahaj K V, Nasar T	Experimental Study on Liquid Sloshing Dynamics with Single Baffle in a Sway Excited Tank
9.	426	Karanam Raviteja, M Uma Maheswar Rao, K.C. Patra	Forecasting of Natural Disasters, A Case Study on Coastal Part of Odisha
10.	470	Anil Bagwan, Jireshwar Sinha, Prabhat Chandra	Mathematical Modelling and Simulation of Ocean Disposal of Harbour Dredged Materials

## PARALLEL SESSION 2/SERVER 2

Time: 02:10 PM to 05:20 PM

Theme: River and Coastal Engineering

KEY NOTE SPEAKER	TOPIC
<b>Dr. R N Sankhua, NWDA Hyderabad</b>	Flood control in Indian rivers case study on river Mahanadi and its tributaries flood control measures

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Dr. Prabhat Chandra, CWPRS Pune, 2- Prof. Bandita Barman, SVNIT Surat

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	006	M. Selva Balan, K.V.Manisa, Yash D, Shraddha Khot & Malathi Khole	Flood Estimation Based On Water Surface Velocity using Non-Contact Sensing and Regression Analysis
2.	025	Jagadeesh H.B., Chalawadi A. S. & Prabhat Chandra	Hydraulic Physical Model Studies For The Development Of Coast Guard Jetty At New Mangalore Port, Panambur, Karnataka – A Case Study
3.	167	Jagadeesh H B, Kashyape P A, Prabhat Chandra	Suitability of Regular And Random Sea Wave Generators In Hydraulic Physical Model Studies - Key Factors For Selection
4.	174	N Jha, J Sinha, Prabhat Chandra	Assessment of Littoral Drift And Shoreline Changes For A Fishery Harbour on South West Coast of India
5.	175	Vighe K S, Barve K H, Ranganath L R, Agrawal J D	Assessment Of Wave Tranquillity And Littoral Drift Studies Using Time Dependent Wave Parameters To Develop Tourist Harbour In Andhra Pradesh

6.	176	Vighe K S, Sawant Rahul, Barve K H, Ranganath L R, Agrawal J D	Numerical Model Studies For Assessment Of Wave Tranquility And Littoral Drift For Proposed Passenger Jetty In An Inlet Harbour At Kalingapatnam.
7.	177	Santosh Kori, Dr Prabhat Chandra	Wave Hindcasting And Storm Surge Analysis At Porbandar, Gujarat
8.	178	R.K.Chaudhari, S.K. Kori, Dr. Prabhat Chandra	Importance Of Optimization Of Over Lapping Of Breakwater At Fishing Harbour Entrance
9.	179	R. K. Chaudhari, S. K. Kori, Dr. Prabhat Chandra	Utilization Of Numerical Model For Shoreline Changes To Evolve The Suitable Coastal Protection Work At Hosabettu, Karnataka
10.	180	Dr. Prabhat Chandra, R.K.Chaudhari, S.K. Kori	Shoreline Changes Studies For Development Of Passenger Terminal At Kashid, Maharashtra

### PARALLEL SESSION 3/SERVER 3

Time: 2:10 PM TO 5.20 PM

Theme: Impact of Climate Change on Water Resources

KEY NOTE SPEAKER	TOPIC
Prof. T I Eldho, IIT Bombay	Climate Change and Land Use Impact Assessment on Hydrology- A Regional Scale Approach

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Dhanya C.T., IIT Delhi, 2- Dr. M. R. Bhajantri, CWPRS Pune

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	016	Priyank Agrawal, H. L. Tiwari and Ankit Balvanshi	Effect of Climate Change on Precipitation for Bhopal, India
2.	048	N. Sahoo, P. K. Das & J. Meher	A Morphological Comparison of Two Different Climatic Settings And Its Significance on Their Sediment Yield
3.	091	Femin C Varghese, Subhasis Mitra	Sensitivity change of water deficit droughts on evapotranspiration methods in the Indian subcontinent
4.	132	Lini R. Chandran, Aiswarya B. Babu, Krishna Priya S. B., Sumina, Sini S. Nair	Generation of Intensity-Duration-Frequency Curve For A River Basin In South Kerala By Incorporating Climate Changes
5.	152	Parth Sinroza, Mohdzuned Shaikh	A Review On Climate Change Impact Analysis Using Statistical Tools
6.	370	Priyank J. Sharma, Ramesh S. V. Teegavarapu	Climate Variability Influences on Seasonal Precipitation-Temperature Associations across Florida

7.	419	Barokar Y. J., Regulwar D.G	Assessment of Climate Change for Generating Grid Wise Future Scenarios of Precipitation and Temperature Over Lower Godavari Sub Basin Maharashtra State, India.
8.	420	Nirup Sundar Mandal, Sanat Nalini Sahoo	Effect of Climate Change on the Precipitation of Saraikela-Kharsawan District of Jharkhand by Statistical Downscaling Method
9.	421	Narapareddi Manasa, M Uma Maheswar Rao, K.C. Patra	Ranking of CMIP6 based Global Climate Models for Prediction of Temperature in Godavari river basin
10.	463	Sushree Swagatika Swain, Ashok Mishra, Chandranath Chatterjee, Bhabagrahi Sahoo	Climate Change or Land-Use Dominated Streamflow Variations: An Empirical Model-Based Contribution Analysis of the Baitarani River Basin, India

## PARALLEL SESSION 4/SERVER 4

Time: 2:10 PM TO 5.20 PM

Theme: Hydraulic & Hydrologic Modelling

KEY NOTE SPEAKER	TOPIC
Prof. C.S.P. Ojha, IIT Roorkee	Evolution of Rainfall-Runoff Models.

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. M. L. Kansal, IIT Roorkee, 2- Dr. R. Manjula, NIT Trichy

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	120	Biltu Pal, Prof. Mahender Choudhary, Prof. Y.P. Mathur	Rainfall-Runoff Simulation in Mahi Bajaj Sagar Dam Catchment, India, Using HEC-HMS
2.	209	Shubham M. Jibhakate, P. V. Timbadiya, P. L. Patel	Prediction of Water Level/Runoff Using Physics Based Hydrological Model in Lower Tapi Basin, India.
3.	212	Lalit Kumar Gehlot, P. L. Patel and P. V. Timbadiya	Identification of Hydrologically Efficient Regions in Semi-Arid Yerli Sub-Catchment of Upper Tapi Basin, India.
4.	224	Arun Kumar, Dr. R. G. Patil	Activation of Central Channel Using Novel Method In River Kosi, Bihar
5.	244	Nikita Saptarishy, P. L. Patel	Development of a distributed physics hydrological model for prediction of inflows into Hathnur Reservoir from Main Tapi River in Upper Tapi basin, India.

6.	258	Anju B, Drissia T.K, Nowshaja P.T	A comparison between Flood models developed using topographical details from field survey and SRTM DEM using MIKE HYDRO River
7.	269	Darshan Mehta, Dr. S. M. Yadav, Ankita Patel	A Rainfall- Runoff Simulation Model for Estimation of Floods for Purna River Basin Part of Upper Tapi Basin
8.	270	Anil Purohit, Animesh Basu, Kumar Chavan, Jagottam Agrawal	Hydrodynamic Challenges And Role Of Physical Model In Evolving Layout of Boat Landing Facility at Confluence of Elephanta Deep And Nhava Creek
9.	281	M. Sayan, P.V. Timbadiya	Hydrodynamic Modelling of Upper Tapi River, India
10.	312	R. R. Bhate, Amit Kulhare, Dr. M. R. Bhajantri	Optimization Of Common Energy Dissipator For The Two-Tier Spillway

## PARALLEL SESSION 5/SERVER 5

Time: 2:10 PM TO 5.20 PM

Theme: RS/GIS Application for Water Resources Management

KEY NOTE SPEAKER	TOPIC
Prof. D. Nagesh Kumar, IISc Bangalore	Remote Sensing and GIS for Flood Inundation Mapping

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Z. Ahmed, IIT Roorkee, 2- Dr. Arpit Chouksey, IIRS  
Dehradun

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	019	M L Harshavardhan, Anirban Mandal	Study on Vegetation, Rainfall pattern and Temperature for the state of Maharashtra
2.	036	Ankan Jana, Prof. Mahesh Kumar Jat & Prof. Mahender Choudhary	Estimation of surface heat fluxes using Remote Sensing Method
3.	037	Shradhha Kuwar, Sunil Gaikwad and Makarand Kulkarni	Assessment of grape crop acreage using geospatial technique for command area of Palkhed Reservoir (Maharashtra)
4.	038	Anita Morkar, Santosh Wagh & Makarand Kulkarni	Hydro-cover Mapping by Remote Sensing and GPS Technology: A case study of Nashik District, Maharashtra, India.
5.	070	Shasanka Sekhar Barik, Dr. Janhabi Meher, Laxmipriya Mohanty	Impact of land use land cover on the response of the Mahanadi river basin in a sub-basin scale using SWAT

6.	102	Sreelakshmi C V and Jairaj P G	Comparison of Land Surface Temperature for Bare soil from MODIS and ASTER data
7.	164	Rolland Andrade	Hydrological Geophysical and GIS Approach in Delineation of Suitable Artificial Recharge Site
8.	219	Mani Kumar Singh, Vivekanand Singh	Estimation of Soil Loss from Bagmati River Basin using RUSLE model and GIS Technique
9.	235	Jotsana G. Ambekar, B. Raghuram Singh, Dr. R. G. Patil	Studies For Proposed Bank Protection Works Along Existing Ghats of Nira And Bhima Rivers At Nira Narsingpur - A Case Study
10.	411	Tufa Feyissa Negewo, Arup Kumar Sarma	Assessment of Water Balance Components in the Genale River Basin, Ethiopia Using SWAT Model

## PARALLEL SESSION 6/SERVER 6

**Time: 2:10 PM TO 5.20 PM**

**Theme: River Hydraulics**

KEY NOTE SPEAKER	TOPIC
<b>Prof. S. Dutta, IIT Guwahati</b>	Geoinformatics Perspective of Urban Floods in Developing Countries

### PARALLEL SESSION PRESENTATIONS

**Session Chairpersons: 1- Prof. H. L. Tiwari, MANIT Bhopal, 2- Dr. Thiyam Tamphasana Devi, NIT Manipur**

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	011	Anurag Sharma, Nikhitha Elsa Sam, Asmita Tanwani, Hardipsinh Jadeja & Bimlesh Kumar	Experimental Investigation of Friction Factor in Alluvial Channel
2.	047	Ashish A. Doshi & Pramod B. Deolalikar	Effect of Dense Stream bank Vegetation With Steep Sloping Riverbanks on Manning's Roughness Coefficient of 0.11 In Hydraulic Model Studies
3.	087	Tushar Khankhoje, Susmita Ghosh	Discharge Predictions of Meandering River using Artificial Neural Networks
4.	122	Gurusamy B. T, Vasudeo A. D, Gautam N.R, Godbole S. P and Ghare A. D	Investigation of The Issues in The Inter Linking of Rivers: A Case Study for Godavari-Krishna Link Indira Sagar Polavaram Project
5.	143	M. Selva Balan, Pratiksha Mete, Ruchita Pagar, Harshada Shelkande , Dipali Bangar	MEMS Based Remote Operated Bed Profiler For River Model
6.	286	K. B. Baladaniya, P. L. Patel	Hydrodynamic Modelling Of Middle Tapi River Using MIKE 11

7.	293	G. Yatirajulu and P. V. Timbadiya	Simulation of Channel Bed Level Variation And Its Experimental Validation
8.	298	Anjana Ramesh, Reeba Thomas	Water Security Assessment of Karuvannur Watershed - Current And Future Scenario
9.	307	Vineela Nandam, Patel P. L	Evaluating Periodic Changes of River Discharge Carrying Capacity: A Case Study of Lower Tapi River
10.	460	Kshyana Prava Samal, Tanmay Mohanty, Babita Das, Kumar Jeeb Pegu	Conceptualization and confrontation strategies for water inequity

**Invited Speaker -3**

**Prof. M Hanif Chaudhry, USC, USA**

**Time: 5:30 pm to 6:10 pm**

**Topic: How Reliable are the Results of Transient-Flow Models?**

**Invited Speaker -4**

**Prof. Chittaranjan Ray, University of Nebraska-Lincoln, USA**

**Time: 6:10 pm to 6:50 pm**

**Topic: How best to manage Odisha's water resources for economic growth and future sustainability?**

**DAY 2**  
**27<sup>th</sup> March 2021 (Saturday)**

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**Invited Speaker -5**

**Prof. Evan Davis, University of Alberta, Canada**

**Time: 8:30 am to 9:10 am**

**Topic: A Systems Approach to Water Resources Planning and Management**

**SECOND TECHNICAL SESSION**

**PARALLEL SESSION 1/SERVER 1**

**Time: 09:20 AM to 12:30 PM**

**Theme: Coastal and Ocean Engineering**

KEY NOTE SPEAKER	TOPIC
<b>Prof. Dwarakish G. S., NITK Surathkal</b>	Geoinformatics in Coastal and Ocean Engineering

**PARALLEL SESSION PRESENTATIONS**

**Session Chairpersons: 1-Prof. Dwarakish G. S., NITK Surathkal, 2- Prof. R. Vinnanasi, IIT  
Roorkee**

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	081	B. Krishna, G. A. Rajkumar, Karthikeyan. M, L.R. Ranganath, J.D Agrawal	Numerical Model Studies to Assess the Morphological Changes due to Coastal Front Development- A Case Study
2.	184	Priyen Somaiya, Raghavendra G. Patil and M C Deo	Historical and Future Sea Level Rise at Major Indian Ports
3.	190	V. B. Sharma, Shivani Sahu, Vaibhav Konde, Prabhat Chandra	Stabilization of Inlet And Restoration Of River Mouth In Puthiyangadi

4.	194	Shivani Sahu, Jiweshwar Sinha, Vaibhawi Roy, Prabhat Chandra	Restoration of tidal creek inlet for navigation using pile jetty - a case study
5.	200	Akhila Padmajan, Rameeza Moideen, Manasa Ranjan Behera	Estimation of Wave Loads on Deck Structures at Indian Ports in a Changing Climate
6.	204	Vishwanatha Mane, Subba Rao, A.Vittal Hegde	Effect of wave steepness on wave overtopping discharge of an emerged quarter-circle breakwater
7.	222	Pranav Vaishampayan, Amol S. Borkar, Varun Khengare, Ketan Jadhav, Abhishek Deshmukh, Prof. Shilpi Bhuinyan, Dr. Prabhat Chandra	Numerical Modelling for Wave Transformation along the Ratnagiri Coast- Case Study
8.	243	Sarath Suresh, Rameeza Moideen, Manasa Ranjan Behera	Effect of Marine Growth on Wave Loading on Small Diameter Tubular Structural Members
9.	261	Aleena Elsa Mathew, Ram Kumar J, Satya Kiran Raju, Sridhar Muddada, M V Ramanamurthy	Performance Evaluation of Detached Breakwater in Poonthura Coast using Boussinesq Wave Approach
10.	416	Bejay Kumar Yadav, Showmen Saha	Behaviour of Rubberized Concrete when Subjected to Exposure Along Coastal Zone

## PARALLEL SESSION 2/SERVER 2

Time: 09:20 AM to 12:30 PM

Theme: Hydraulic & Hydrologic Modelling

KEY NOTE SPEAKER	TOPIC
Prof. P. L. Patel, SVNIT Surat	Impact of Climate Variability on Water Security of Tapi Basin.

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. S. K. Biswal, NIT Agartala, 2- Prof. K. V. Jaykumar, NIT Warangal

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	035	Uday B. Patil, Dr. Prabhat Chandra	Mathematical Model Studies For Construction Of Temporary Pile Bridge For Erection Of Fly Over Bridge Across An Estuarine River
2.	125	Dr. Munendra Kumar and Mr. Jaganniwas	Evaluation of Run-Off and Its Impact on Confluence of Tributary Due to Rapid Urbanization in Shipra River Basin
3	128	Dr. Munendra Kumar and Mr. Jaganniwas	Selection of the Optimal Design Run-off Coefficient for Urban Drainage System
4	186	G. V. R. Murthy, Y. N. Srivastava, V.S. Telgote	Mathematical Model Studies for Surge Analysis of Haldi Purani Lift Irrigation Schem
5	205	Sudheer S. Chavan, Hradaya Prakash Dr. Prabhat Chandra	Utility Of Physical Wave Model For The Development Of Fishing Harbour On Open Coast
6	208	M. S. Bist, Ajay Sonawane, Ajit Singh, J. K. Singh, M. Selva Balan	Acquisition of Depth Profile Using Bathymetry Survey Near Left Bank Spillway And Proposed Additional Spillway Of

			Hirakud Dam, Odisha - A case study
7	220	Chaudharee B. B, Hradaya Prakash, Dr.Prabhat Chandra	Morphological Changes Around Sogal Channel of Deendayal Port, Gujarat In the Approaches
8	450	A. Pardeshi, A. S. Borkar, B. L. Meena, Dr. Prabhat Chandra	Wave Simulation for Optimization of Breakwater Layout- A Case Study.
9.	492	Pranaya Keshari Nahak, Adwaith Gupta	Numerical Simulation of Energy Loss at Drops mechanism by Volume of Fluid Method
10.	507	Ratnakar Swain	Impact of deforestation and urbanization on extreme temperature and humidity over Brahmani River Basin

### PARALLEL SESSION 3/SERVER 3

Time: 09:20 AM to 12:30 PM

Theme: Flood Forecasting and Management

KEY NOTE SPEAKER	TOPIC
<b>Prof. C. Madhusudana Rao, NIT Jamshedpur</b>	Application of simplified routing methods for hydrometric data-based real-time flood forecasting

#### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Deepak Khare, IIT Roorkee, 2- Prof. C. Madhusudana Rao, NIT Jamshedpur

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	014	Soumya S Nyamathi & Dwarakish G.S	Flood Frequency Analysis Using Gumbel's Distribution Method: A Case Study of Sita River, Karnataka, India.
2.	066	Amina Khatun, Chandranath Chatterjee, Bhabagrahi Sahoo	Investigating the role of streamflow forecasts to mitigate floods in the delta region of Mahanadi River basin
3.	088	Athira K, Dr. Sarmistha Singh	Flood risk assessment and mapping using AHP: A case study in Thuthapuzha river basin, Kerala
4.	097	Amit Kumar Singh, Sagar Rohidas Chavan	Application of L-Moment based Regional Flood Frequency Analysis for Krishna River Basin
5.	202	Sachin Bhere, M. Janga Reddy	Assessment of floodplain mapping of Ulhas River basin using HEC-RAS1D/2D hydraulic simulation

6.	249	Jeslin Jose A, Dr. Sumam K S	Flood Inundation Mapping of Chalakkudy River using HEC RAS
7.	291	Anjitha U.G., Meera G.Mohan, Adarsh S, Gopakumar R	Non-stationary Flood Frequency Analysis of West flowing Rivers of Kerala using Bayesian Inference Approach
8.	458	V. Jagadeesh, R. S. Erande	Web Interface for Random Sea Wave Generation and Data Acquisition System for Hydraulic Physical Model Studies
9.	462	R. Venkata Raman, V.S. Jeyakanthan, Y.R. Satyaji Rao and T. Vijay	2-D Flash Flood Modelling of Vamasadhara River basin
10.	490	Dev Vrat Singh, Saurabh Agnihotri, Javed Alam and Mohd. Muzzammil	Flood Resistant and Amphibious Houses: An Overview

## PARALLEL SESSION 4/SERVER 4

Time: 09:20 AM to 12:30 PM

Theme: Urban Water Management

KEY NOTE SPEAKER	TOPIC
Prof. Pranab Mohapatra, IIT Gandhinagar	Detection of Partial Blockage in Piping System

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Anil Kar, VSSUT Burla, 2-Dr. Ray Singh Meena, NIT Hamirpur

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	008	N.A.Sonawane, Kuldeep Malik, Ku. Madhavi Gajre, M.K.Pawar	Assessing Flow Parameters In Sand Nalla in The Vicinity of Mouda STPP of NTPC, Maharashtra
2.	073	Jitendra Yadav, Ruchi Khare, Jyoti Sarup	Morphometric Analysis of Trident Campus of Budhani in Madhya Pradesh
3	161	Susen Sinha, Sandeep Kr. Chouksey	A Study of Greywater Reuse System For An Urban Household
4.	239	S. S. Kerimani, S. P. Hedao, R. G. Patil	Alignment of RRTS Railway Bridge Across River Yamuna for Delhi-Ghaziabad- Meerut Corridor at New Delhi: A Case Study
5.	256	Bahar Adem Beker and Mitthan Lal Kansal	Issues and Challenges of the Urban Water Supply System in Ethiopia: A Case Study of Dire Dawa
6.	275	S N Poojitha, Gagandeep Singh, Vinayakam Jothiprakash	Evolutionary Optimization Techniques for Optimal Design of Water Distribution Networks

7.	292	Aspruha Swain, Prof. Ashwani Kumar	Water Urbanism: Strategies for stormwater management through rainfall-runoff analysis using SCS-CN method and GIS in watersheds of Ajmer, Rajasthan
8.	309	Jyothi Prakash Arkadu, Seetarami Naidu Malla, Abdul Rahiman P M, Ramappa Govindappa Patil	Transient Analysis for Water Supply Pipeline for Pokaran Villages
9	454	Anushri Barman, Dr. Ramakar Jha	Traditional stormwater management system in watershed of wetland, a study and overview of “Dong” systems in wetland fringe villages of Assam
10	477	Umesh Meena, K. K. Khatua	An Overview of Dam Failure and It’s Analysis Methods

## PARALLEL SESSION 5/SERVER 5

Time: 09:20 AM to 12:30 PM

Theme: Watershed Management

KEY NOTE SPEAKER	TOPIC
Prof. V. R. Desai, IIT Kharagpur	Sustainable water management through promotion of voluntary afforestation

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Rabindra Kumar Panda, IIT Bhubaneswar, 2- Prof. S. G. Thampi, NIT Calicut

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	012	Mridula Sharma & Arun Goel	Variability Analysis of Hydrological Parameters of Faridabad District (Haryana State)
2.	057	C. Reshma & R. Arunkumar	Comparison of spatial interpolation methods for filling missing observations in daily rainfall data
3.	133	Smaranika Mahapatra, Madan K. Jha	An environment concerned risk based approach for evaluating watershed health
4.	169	Jagannath Patro, Vazeer Mahammood	Surface Water Balance Study of River Sarada
5.	181	Arunav Nanda, Dr. Bhaskar R. Nikam, Dr. Vaibhav Garg, Dr. S.P. Aggarwal	Analysing the Response of Meteorological Droughts on Stream Flow in the Pennar River Basin
6.	253	C. Srishailam, N. Vivekanandan, R.G. Patil	Estimation of Peak Flood Discharge for Ungauged Catchments By Hydrometeorological Approaches
7.	266	Souvick Kumar Shaw, K. K. Khatua	Flood Routing In A River By Modified Pul's Method

8.	276	Jagpreet Singh Kamboj, Sahibpreet Singh, Mahesh Patel	Wastewater Management through Water Drainage System: A Case Study
9.	317	Raviraj Dave, Udit Bhatia	River Discharge Estimation Using SARIMA Model And OLS Regression From Satellite Altimetry Data –A Case Study Of Amazon River
10.	390	Vikas Poonia, Manish K. Goyal	Distribution, Trend, and Concurrence of Meteorological, Hydrological and Agricultural Droughts over Madhya Pradesh, India

PARALLEL SESSION 6/SERVER 6

Time: 09:20 AM to 12:30 PM

Theme: Hydraulic Structures and Hydropower Engineering

KEY NOTE SPEAKER	TOPIC
<b>Prof. L. R. Ranganath, Scientist E, CWPRS</b>	Evaluation of a navigational channel in Tapi estuary through model studies

PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Dr. H. B. Jagadeesh, CWPRS Pune, 2- Dr. Manoj Langhi, IITRAM, Ahmedabad

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	005	Karan Solankia & Himanshu Sharmaa	Flow Pattern Around Multiple Vane Arrangement
2.	024	Shilpi Sippi Bhuinyan& Prof. Dr. Anand Kr. Sinha	Study of Energy Dissipator with Different Blocks to Reduce Basin Width and Trajectory : A Review
3.	039	Pradyumna Machhkhand	Hydraulic modelling of headpond with lateral spillway weir structure for the Tamskoshi-V hydroelectric project, Nepal
4.	076	Ankur Kapoor, Aniruddha D. Ghare, Avinash M. Badar	Stage discharge relationship by weir theory for channel flow measurements using the conical central baffles
5.	082	Deepak Singh and Munendra Kumar	Study on Aeration Performance of P.K. weir with its Alternatives: A Review
6.	103	Saurabh Sah, Munendra Kumar	Study of Flow Characteristic Of Rectangular Labyrinth Weir

7.	110	Neha S. Baghele, Anjali K. Khambete, Robin A. Christian	Hydrodynamic Cavitation: A Treatment to Secondary Effluent of STP to Reuse
8.	148	Satyajeet Sinha	New Methodology of Optimisation of Water Conductor System in Hydropower
9.	165	Ruchi Khare, Vishnu Prasad, Chinky Yadav	Numerical Simulation to Study Cavitation Characteristics of Centrifugal Pump
10.	321	Ajit Singh, Mahender Singh Bist, Ajay Sonawane, K Subbarao Murthy, M Selvabalan	Estimation of Reservoir Capacity of Singda Dam, Manipur using Modern Integrated Bathymetry System (IBS) – A case study

**Invited Speaker -6**

**Prof. Xianon Tang, Xi'an Jiaotong-Liverpool University, China**

**Time: 12:30 pm to 01:10 pm**

**Topic: Analytical modelling for predicting the flow velocity in vegetated channels.**

**Invited Speaker -7**

**Prof. Nigel Wright, Deputy Vice-Chancellor for Research and Enterprise at Nottingham**

**Trent University, UK**

**Time: 2:00 pm to 2:40 pm**

**Topic: A Novel Means for Identifying Flood Sources in Urban Areas to Support the Implementation of Sustainable Urban Flood Resilience.**

**DAY 2**  
**27<sup>th</sup> March 2021 (Saturday)**

**THIRD TECHNICAL SESSION**

**PARALLEL SESSION 1/SERVER 1**

**Time: 2:40 PM TO 5:50 PM**

**Theme: Groundwater Modelling and Management**

<b>KEY NOTE SPEAKER</b>	<b>TOPIC</b>
<b>Prof. P. C. Swain, VSSUT Burla</b>	Flood management in tropical countries with special reference to medium and small catchments

**PARALLEL SESSION PRESENTATIONS**

**Session Chairpersons: 1- Prof. P. C. Swain, VSSUT Burla, 2- Dr. Manish Pandey, NIT  
Warangal**

<b>SL. NO.</b>	<b>PAPER ID</b>	<b>AUTHORS</b>	<b>TITLE</b>
1.	027	Uttam Singh and Pramod K. Sharma	Study on Subsurface Hydraulic Conductivity and Soil Moisture using Ground Magnetic Resonance (GMR)
2.	054	Shikha Kataki, Dr. Triptimoni Borah	MODFLOW, MODPATH and MT3DMS based simulation of groundwater flow and leachate transport from landfill
3.	061	Santosh Ojha, Gunwant Sharma, Deepesh Machiwal	Hydro-Chemical Characterization and Quality Appraisal of Groundwater using Water Quality Index in District Jaipur, Rajasthan
4.	221	Sumit Kumar, Vivekanand Singh	Assessment of Groundwater Potential Zones Using AHP Technique in Darbhanga District of Bihar
5.	241	Sunilkumar P S, Dr. Ramesh H	Identification and Mapping Potential zones of Submarine Groundwater Discharge (SGD) along Mangalore to Udupi Coast, Karnataka

6.	242	Ajay, Chidara Nagamanikanta Sai & Om Prakash	Surface Water Groundwater Interactions in Estimating Groundwater Recharge using Genetic Programming
7.	315	Alice Thomas, Eldho T I	A review of evolutionary algorithms in inverse modeling for groundwater flow and transport parameter estimation
8.	417	Puja Tripathy, M. Uma Maheswar Rao, K.C. Patra	Impact of Climate Change on Groundwater Recharge
9.	425	Himanshu Gaikwad, Bhavana Umrikar, Mandira Majumdar, C Krishnaiah	Appraising Prolific Zones of Groundwater in hard rock phreatic aquifers from sub-watersheds of Upper Bhima Basin, Western India using Geospatial and MIF techniques
10.	430	R. A. Panchal, Dr. H. M. Patel	Estimating confined aquifer parameters using Particle Swarm Optimization technique

## PARALLEL SESSION 2/SERVER 2

Time: 2:40 PM TO 5:50 PM

Theme: Computational Fluid Dynamics / Numerical Modelling

KEY NOTE SPEAKER	TOPIC
<b>Prof. Sunil Sarangi, Ex Professor, IIT Kharagpur</b>	An Overview of Industrial Water Supply Systems

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Dr. Kamalini Devi, VJIT Hyderabad, 2- Dr. Vinay Chembolu, IIT Jammu

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	034	Dr. I. Siva Parvathi & Miss. G. PremaSwathi	CFD Analysis of Flow through Concentric, Eccentric and Segmental Orifice Meters
2.	096	Prashant Huddar, VishwanathBhave	Hydraulic Structure Design with 3-D CFD Model
3.	130	Jyotiprakash Tarei, Bandita Barman	Performance of MacCormack finite difference scheme with TVD and Artificial Viscosity
4.	217	Lokesh Mangal, C. Gowri Shankar, Manasa Ranjan Behera	Development of two dimensional 9-noded lagrangian quadratic isoparametric element mesh generation tool for finite element models
5.	254	M. S. Bhadange, R. R. Bhate, Dr. S. D. Khandekar	Application of computational fluid dynamics in investigating orifice spillway flow
6.	257	Anitha Gopinath A., Miji Cherian R.	Study On Influence Of Vegetation In Open Channel Using Cfd Model

7.	277	Rohini Rani, Kishanjit K Khatua, Pravas Ranjan Pradhan	Computation of Gradually Varied Flow depths in a Channel System Using Numerical method
8.	283	Pravas Ranjan Pradhan, Kishanjit Kumar Khatua, Rohini Rani	A solution of Saint-Venant equation using Numerical method
9.	342	G Rahul Indivar, Kishanjit Kumar Khatua	Numerical Simulation Of Undular Hydraulic Jump Using Ansys Fluent
10.	471	Jiweshwar Sinha, S.N. Jha, Vaibhawi Roy, Prabhat Chandra	Numerical modelling in shoreline evolution prediction: case study of inlet channel at Kasargod, Kerala.

### PARALLEL SESSION 3/SERVER 3

**Time: 2:40 PM TO 5:50 PM**

**Theme: Sediment Transport**

KEY NOTE SPEAKER	TOPIC
<b>Shri Jyotirmaya Rath, EIC, WR, Odisha</b>	Erosion and Sedimentation in Coastal Regions

### PARALLEL SESSION PRESENTATIONS

**Session Chairpersons: 1- Prof. Javed Alam, AMU Aligarh, 2- Dr. J. D. Agrawal, CWPRS  
Pune**

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	059	A K Singh, Naval S Jagatap, L. R. Ranganath & J. D. Agrawal	Breakwater Construction Effects on Hydrodynamics And Sedimentation Pattern in Open Coast
2.	063	Kamalini Devi, Bhabani Shakar Das, Jnana Ranjan Khuntia, Gutha Ruthwikesh Reddy, Annepu Laxmi Prasad	Interlinking Prospect of Godavari River with Krishna River
3.	149	Himadri Shah, Sudhanshu S. Dixit, V. M. Patel, Nimrabanu Memon, Dhruvesh P. Patel	Estimation of Sediment Production Rate using Josh and Dash model- A Case Study of Rel River, Banaskantha District
4.	182	A. K. Singh, Naval S. Jagatap, L. R. Ranganath, J. D. Agrawal	Evaluation of Hydrodynamics and Sedimentation Due To Construction Of Jetty
5.	188	V. B. Sharma, M D Sawant, Dr. Prabhat Chandra	Comparison of Sedimentation in Dredged Open Basin And Enclosed Basin– A Case
6.	197	Mayuraksha Bardhan	Erosion of River Ganga Upstream and Downstream of Farakka Barrage- A Review

7.	214	Harapriya Panda, Ratnakar Swain, Bibhuti Bhusan Mukharjee	A Study of Flow and Sediment Transport Analysis using HEC-RAS
8.	237	B. Raghuram Singh, Jotsana G. Ambekar, Dr. R. G. Patil	Flood protection measures and anti-erosion works along Palhori Khala tributary of River Yamuna
9.	250	Maneesha K Sankar, Dr. Suman K. S	Estimation of Sediment Yield in Chalakudy River
10.	300	V. K. Bind, B. K. Samtani	1-D Hydrodynamic Modelling in HEC-RAS for Prediction of Water Levels and Sediment Transport in Narmada River

PARALLEL SESSION 4/SERVER 4

Time: 2:40 PM TO 5:50 PM

Theme: River Hydraulics

KEY NOTE SPEAKER	TOPIC
Prof. K V Jaykumar, NIT Warangal	Modelling of environmental flow requirements using hydrological and habitation models

PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. K. K. Singh, NIT Kurukshetra, 2-Prof. Arindam Sarkar, IIT Bhubaneswar

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	072	Rohit Prabhakar Nayak, Dr. Shivakumar J. Nyamathi	Sediment modelling and trend analysis for Ungauged subwatersheds in Westernghats
2.	123	Ashutosh Pati, Bhabagrahi Sahoo	Applicability of Variable Parameter McCarthy-Muskingum (VPMM) Model for Reverse Flow Routing
3.	126	Jerripotu Gopala Rao, Gunwant Sharma, Sudhir Kumar	Application of Three Models for Estimating Daily Streamflow Simulation in Pulichinthala Sub-basin
4.	151	Pramodkumar Kappadi, Nagaraj M. K., Paresh Chandra Deka	Sensitivity analysis of flood routing parameters in the Nethravathi river basin
5.	157	Snigdha Kalita, P.K. Khaund	Safety Analysis Of Alluvial Riverbanks
6.	199	Jnana Ranjan Khuntia, Kamalini Devi, Bhabani Shankar Das and Kishanjit Kumar Khatua	Turbulent Structures under Unsteady Flow Conditions Through Emergent Rigid Vegetation

7.	226	Krishna Pada Bauri, Arindam Sarkar	Experimental and numerical study of flow around submerged vertical circular cylinder in steady current
8.	334	Pinakana Lakshmanrao, B. Sri Sai Prasad, K.K. Khatua	Analysing Kinetic Energy and Momentum Coefficients In a Meandering Channel With And Without Vegetated Flood Plains
9.	335	Sree Sai Prasad B, P Lakshman Rao, K.K. Khatua	Flow Modelling and Evaluating Impact Of Roughness On Turbulent Flow Properties In Diverging Compound Channel
10.	423	Joseph Sebastian Sibi, Prasit G. Agnihotri, Azaz I. Pathan	Variation of Sediment Transport in Godavari Basin

## PARALLEL SESSION 5/SERVER 5

Time: 2:40 PM TO 5:50 PM

Theme: Urban Water Management/ Irrigation Management

KEY NOTE SPEAKER	TOPIC
<b>Prof. A. K. Gosain, IIT Delhi</b>	Recipe of Achieving Water Security and Sustainable Development of India

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. B. Panigrahi, OUAT Bhubaneswar, 2- Dr. Mahesh Patel, NIT Jalandhar

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	020	Venkata Ramamohan Ramachandrula & Ramamohan Reddy Kasa	Design of anti-clogging drip emitter using CT imaging and deep-learning algorithms
2.	246	Sultana Hadia Rahman, Bibhash Sarma	Optimal Design of Sukla Irrigation Canal
3.	265	Drissia T. K., Saji Simon, Renji Xavier, Smriti Simon, Vivek Devadas and Anitha A. B.	Performance Evaluation of Malampuzha Irrigation Project, Kerala
4.	284	Sangita Vilas Pawar, P.L.Patel and A.B.Mirajkar	Estimation of Potential Evapotranspiration in command area of New Mutha Right Bank Canal, Pune, Maharashtra, India
5.	290	Miji Cherian R., N. Sajikumar, Sumam K. S	Modal analysis for a water carrying piping System
6.	319	P. K. Mishra, Hemant Singh, Renoj J. Thayyen, Swagatam Das, M. K. Nema, Pradeep Kumar	Block level Livelihood Vulnerability Index of a Himalayan district in Upper Ganga Basin
7.	355	Suaiba Mufti, Arghya Das	Insight into the key model parameters of Pore Network affecting SWRC simulation

8.	382	Ephrem Yetbarek, Richa Ojha	Comparison of soil moisture simulations with experimental observations in agricultural fields
9.	489	Yerrupalli Ganesh, M. Uma Maheswar Rao, K.C. Patra	Drought Modelling By Using Artificial Neural Network
10.	493	Santosh Kumar, Yogesh Prakash Mathur	Optimal Design of Sewerage System including Pumping Cost at STP using MPSO

## PARALLEL SESSION 6/SERVER 6

**Time: 2:40 PM TO 5:50 PM**

**Theme: Hydrometeorology**

KEY NOTE SPEAKER	TOPIC
<b>Prof. R. Maity, IIT Kharagpur</b>	Temporal Networks-Based Approach for Non-stationary Hydro-climatic Modelling.

### PARALLEL SESSION PRESENTATIONS

**Session Chairpersons: 1- Prof. R. Maity, IIT Kharagpur, 2- Prof. Mahendra Choudhury, MNIT Jaipur**

SL. NO.	PAPER ID	AUTHORS	TITLE
1	093	Sakila Saminathan, Subhasis Mitra	Post processing short to medium range GEFS precipitation forecast in India
2	101	Haripriya. P. R and Jairaj. P. G.	Study on the Impact of Orography on Rainfall in the Western Ghats region of India
3	121	K Raviprakashreddy, A.D Ghare	Estimation of PMP using Generalized and Statistical method for Krishna Sub-basin
4	140	P. M. Hodlur and R. V. Raikar	Probability Distribution and Frequency Analysis of Consecutive Days Maximum Rainfall at Samba (Belagavi), Karnataka, India
5	280	P.V. Timbadiya, Aarti Ghate, Rakshita Roat	Evaluation of Rainfall Correction Factor for Jaipur City
6	282	Aarti Ghate, P.V. Timbadiya	Evaluation of Conversion Factor and its Effects on Extreme Value Analysis of Rainfall

7	332	Padminee Samal, Prangya Nivedita, Smaranika Panigrahi, Prakash Chandra Swain	Development of Rainfall Intensity-Duration-Frequency (IDF) curves of Ganjam District, Odisha, India
8	362	Soorya Gayathri M, Mahima R Lal, Shehinamol K, Zaina Nizamudeen, Adarsh S	Spatio-temporal Analysis of Extreme Temperature Indices of India using Non-parametric tests
9	473	Sreeraj S, Sarmistha Singh	Indian Teleconnection of ocean Atmospheric Phenomena on Precipitation
10	480	Alka Abraham, Subrahmanya Kundapura	Analysis of rainfall trends and extreme precipitation indices in a humid tropical basin.

**Invited Speaker -8**

**Prof. Pradeep K. Behera, Professor Chair, University of District of Columbia, Washington  
DC, USA**

**Time: 5:50 pm to 6:30 pm**

**Topic: Engineering of Urban Water Systems for 21<sup>st</sup> Century and Beyond for India –  
Challenges and Opportunities**

**DAY 3**  
**28<sup>th</sup> March 2021 (Sunday)**

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**Invited Speaker -9**

**Prof. Ashok Mishra, Clemson University, USA**

**Time: 8:00 am to 8:40 am**

**Topic: Hydro climatic Extremes: Compound Drought and Heatwaves.**

**Invited Speaker -10**

**Prof. Debabrata Sahoo, Sustainable Water Resources, Clemson University, USA**

**Time: 8:40 am to 9:20 am**

**Topic: Digital Water-The technological wave to manage, analyse, and inform hydrologic assets.**

**FOURTH TECHNICAL SESSION**

**PARALLEL SESSION 1/SERVER 1**

**Time: 9:40 AM TO 12.50 PM**

**Theme: Hydraulic & Hydrologic Modelling**

KEY NOTE SPEAKER	TOPIC
<b>Prof. Manas Ranjan Behera, IIT Mumbai</b>	Coastal Vulnerability in a Changing Climate

**PARALLEL SESSION PRESENTATIONS**

**Session Chairpersons: 1-Prof. Manas Ranjan Behera, IIT Mumbai, 2- Prof. H. J. Shiva Prasad, GBPUAT Uttarakhand**

SL. NO.	PAPER ID	AUTHORS	TITLE
1	189	Dr. Prabhat Chandra, V. B. Sharma, Vaibhav Konde	Impact of Deepening of Approach Channel For New Mangalore Port – A Case Study

2	201	Kishanlal Darji, Dhruvesh Patel, Indra Prakash	Application of SCS-CN Method and HEC-HMS Model in the Estimation of Runoff of Machhu River Basin, Gujarat, India
3	294	Ramnas K.C, Drissia T. K., Anaz A., Nikhil, K Ch V Nagkumar, V P Dinesan	Landuse/land cover change impact assessment on stream flow over Vamanapuram river basin, Kerala
4	306	Alka Sharma, P. L. Patel	Relative performance of Continuous and event based hydrological models for Dharoi sub-catchment of Sabarmati basin in India
5	350	Anju K V and P. L. Patel	Development of Hydrological Model (Mike 11 Nam) for Simulation of Stream Flows at Burhanpur Station in Upper Tapi Basin, India
6	353	Bhabani Shakar Das, Kamalini Devi, Jnana Ranjan Khuntia, K K Khatua	Prediction of discharge in non-prismatic compound channel using Extended ISM
7	401	Sabinaya Biswal, Bhabagrahi Sahoo, Madan K. Jha and Mahendra K. Bhuyan	Comparative Evaluation of SRTM and MERIT DEMs in Simulating Streamflow Dynamics in a Complex Deltaic River Basin
8.	402	K. K. Nandi, C. Pradhan, J. Sultan, S. Dutta, K. K. Khatua	Energy Dissipation Modeling in Highly Braided Brahmaputra River
9.	479	Vidya Elizabeth Jacob and Subrahmanya Kundapura	Hydrological Modelling of Nethravathi Basin Using SWAT
10.	453	R. P Gupta, H. R. Khandagale, Mukesh Kumar, Milankumar Someshwara	Performance Testing of Paddle Wheel Current Meters – A Case Study

PARALLEL SESSION 2/SERVER 2

Time: 9:40 AM TO 12.50 PM

Theme: Hydraulic & Hydrologic Modelling

KEY NOTE SPEAKER	TOPIC
Prof. Subba Rao, NITK Surathkal	Analysis of coastal erosion problems in the vicinity of Netravathi-Gurpur river estuary, west coast of India- a modelling approach

PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. Subba Rao, NITK Surathkal, 2- Dr. L. R. Ranganath,  
CWPRS Pune

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	094	Anshuman Samal, Ishtiyag Ahmad, Surjeet Singh	Simulation of Leaching Process Of Heavy Metals in the Vadose Zone under Wastewater Application
2.	168	Ayisha Noon.T.k and Jairaj.P.G.	Water Quality Assessment using Probabilistic and Possibilistic Measures
3.	210	Kedar Sharma	Chambal Crocodile Sanctuary: Factors Make it a Pollution Free River Stretch
4.	223	Mrigendra Kumar, Prof. (Dr.) Ramakar Jha	Physico Chemical Analysis of the Industrial Effluent and Sewage Their Effect on the Water Quality and Soil of Getting River Harmu in Ranchi
5.	302	Meera G Mohan, Jobin Boben, Greeshma G, Melvin Mathew, Libin Thomas	Surface Water Quality Assessment Of Keno Reach Of Klamath River Using PCA - Entropy Model
6.	330	Mark Prabhakar Vuppati, Mahesh Game, Kishore Kumar Swain, Neena Isaac	Spatial variation in water quality of Mula-Mutha river flowing through Pune city and suburbs, Maharashtra

7.	339	Sarjati Sahoo, Kamalini Devi, Jnana Ranjan Khuntia, Kishanjit Kumar Khatua	Study of Unsteady Flow Parameters and Hysteresis Effect in a Simple Channel under Unsteady Flow Condition
8.	445	Sayanta Ghosh, Gaurav Sharma, Renu Lata, 4J.C. Kuniyal	A GIS-based Seasonal Water Quality Profiling of Parbati River, Himachal Pradesh, India
9.	452	Subhankari Mohapatra, Dr. Rakesh Roshan Dash	Use of phytoremediation method for removal of hexavalent chromium by eichhornia crassipes
10.	464	L. N. Thakural, Shahana, Mohd. Izharuddin Ansari, Shayaan Ali, Ashish Bhandari, Aradhana Thakur	Statistical Analysis of Long-Term Rainfall for the Districts of Gujarat, India

### PARALLEL SESSION 3/SERVER 3

Time: 9:40 AM TO 12.50 PM

Theme: RS/GIS Application for Water Resources Management

KEY NOTE SPEAKER	TOPIC
Prof. V. Jothiprakash, IIT Bombay	Sedimentation rate and behavior analysis using chaos theory

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. Ramakar Jha, NIT Patna, 2- Dr. Sanjay K. Jain, NIH Roorkee

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	053	Chandan Jyoti Saikia, Dr. Triptimoni Borah	A Study on the Impact of Water Pollution due to Dumping of Waste in the Deepor Beel, Guwahati, Assam
2.	080	Sumanth A, H Ramesh	Hydrological Modeling of the Upper Cauvery River Basin Using SWAT
3.	170	Sowmya Nj, Apoorva R, Deviprasad, Anunaya, Kiran, Prasad Pujar	Estimating the impacts of Land use and Land cover on soil properties of Puttur
4.	228	Biswajit Pradhan, Kisanjit Kumar Khatua, Prakash Chandra Swain	Dynamics of land use and land cover change (LULC) using geospatial techniques: A case study of Mahanadi River basin, Odisha.
5.	230	Vinay Pandey, Vivekanand Singh and Chandan Raj	Study of Morphological Changes of the River Ganga from Patna to Mokama during 1975 to 2019 using satellite imageries
6.	236	Y. R .Bhagat, J. A. Shimpi	A Comparative Study on the Air Temperature Trends in Coastal And Inland Region of India

7.	267	Nirmal Krishnan A. K. and N. Sajikumar	Landslide prediction in Western Ghats using TRIGRS model
8.	366	Namitha Thomas, H. Ramesh	Flood risk mapping of Netravati river basin using remote sensing and GIS techniques
9.	435	Lakshmi Raghu Nagendra Prasad Rentachintala, M.G.Muni Reddy, Pranab Kumar Mohapatra	SWMM based Integrated Urban Stormwater Management for a Water Sensitive City: A Case Study of Proposed Amaravati City, Andhra Pradesh
10.	483	Durgasrilakshmi Hari, K. Ramamohan Reddy, Vankayala Harish	Vulnerability Zoning of Urban Flood Using Remote Sensing and GIS in Hyderabad, India

## PARALLEL SESSION 4/SERVER 4

Time: 9:40 AM TO 12.50 PM

Theme: Soft Computing Techniques in Water Resources

KEY NOTE SPEAKER	TOPIC
Prof. D. P. Acharya, NIT Rourkela	Intelligent IoT for Water Resource Management

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. Arun Goel, NIT Kurukshetra, 2-Prof. Sanjay Kumar M. Yadav, SVNIT Surat

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	015	Biprodip Chaudhuri, H.L. Tiwari, R.K. Jaiswal and Ankit Balvanshi	Assessment of Revised Capacity of Tawa Reservoir using QGIS tool
2.	044	Kruti Joshi, Shreenivas N. Londhe	Estimation of Precipitation Using Support Vector Regression
3.	138	Devaki Nandan, Vishal Kapoor, Vinod Tare	Water Management of Upper Ganga Canal Command Area Using Teaching Learning Based Optimization Algorithm
4.	171	Sachin Dadu Khandekar, Paresh Chandra Deka, Varsha Sachin Khandekar	Maximum and Minimum Temperature Prediction using Hybrid Wavelet Transform – Neural Network Approach: A Case Study of Mahabaleshwar City
5.	287	Pradnya Dixit, Aditi Bhavar, Pravin Kolhe, Shreenivas Londhe, Preeti Kulkarni	Forecasting of Koyana Reservoir Outflow Using M5 Model Tree
6.	325	Pravin Bhasme, Anshuman Yadav, Udit Bhatia	Streamflow Prediction Using The Hybrid Approach
7.	367	Mrutyunjaya Baliarsingh, K. K. Khatua	Gene Expression Programming for Prediction of Friction Factor in OC Flow

8.	434	Kushang V. shah, Prof. (Dr.) H. M. Patel	Development of Leak Detection Techniques in Water Distribution System using Combined Machine Learning and Statistical Approaches
9.	461	Sanjay Dhiman, Suresh Khandelwal	Support Vector Regression And Neural Network Based Predictive Modeling Of Evaporation
10.	474	A.R.Mengade, S.N.Londhe, P.S.Kulkarni, P.R.Dixit	Correlating Stream Gauge stations using Multigene Genetic Programming

## PARALLEL SESSION 5/SERVER 5

Time: 9:40 AM TO 12:50 PM

Theme: Hydraulic Structures and Hydropower Engineering

KEY NOTE SPEAKER	TOPIC
Er. Ashutosh Dash, CE cum Additional Secretary Deptt. of Water Resources, Govt. of Odisha	UTTARAKHAND FLOOD – 2021: REASONS AND LESSONS TO LEARN

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Dr. M. Selvabalan, CWPRS Pune, 2- Prof. M. K. Goel, NIH  
Roorkee

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	074	Sanjib Gohain, Bipul Talukdar	Causes and Ecological Impact of Embankment Breaching in Dhemaji District
2.	075	Chitrangini Sahu, T. I. Eldho	Turbulent Flow Characteristics Around Group of Circular Bridge Piers Over Plane Rigid Bed
3.	203	Piya Biswas, Abdul Karim Barbhuiya	Three Dimensional Flow Dynamics in a Bend Channel With Scour Protection as a Combination of Submerged Vane And Riprap
4.	245	P.K Suresh, R. Sundaravadivelu, R. Radhakrishnan, Ambalavanan, Muthiah, K Asokan	Design of Conservation Measures in Palar River of Tamilnadu
5.	247	B.A. Vijayasree, T.I. Eldho and B.S. Mazumder	Effect of Inline Spacing Between Twin Bridge Piers On The Scour Pattern
6.	260	Pushparajan E K, Miji Cherian R.	Seepage Analysis of Earth Dam based on Numerical Methods

7.	295	Mrs. Sushma Vyas, Shri Y. N. Srivastava	Physical and Numerical Study for Flow over Spillway Profile of Kiru Hydroelectric Project, J & K)
8.	318	Rony J.S. and D. Karmakar	Hydrodynamic Performance of Array of Heaving Point Absorbers Combined With STLP-Type Floating Wind Turbine
9.	324	Reeti R. and D. Karmakar	Dynamic Analysis Of Array Of Heaving Point Absorbers Combined With Semi-Submersible Floating Wind Turbine
10.	428	Satya Narayana Bhuyan, M Uma Maheswar Rao, K.C. Patra	Dam Break Analysis of Nagarjuna Sagar Dam Using HEC-RAS

PARALLEL SESSION 6/SERVER 6

Time: 9:40 AM TO 12:50 PM

Theme: Groundwater Modelling and Management

KEY NOTE SPEAKER	TOPIC
Prof. Rajib Bhattacharya, IIT Guwahati	Status and Management of Groundwater in India

PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. V. Garg, CUH Haryana, 2- Dr. A. K. Singh, CWPRS, Pune

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	003	N.C. Mondal	Determining Hydro Chemical Backgrounds In A Part Of Krishna Delta To Implicating Mass Transport Modeling
2.	050	Ruchi Khare & Indraneel Singh	An Approach To Delineate Groundwater Recharge Potential Sites In Rajgardi District, Madhya Pradesh Using GIS Techniques
3.	079	Hadi Ahmed & Triptimoni Borah	Development Of An Efficient Methodology For Improving Ground Water Recharge By Hydrus 1 D
4.	085	Aatish Anshuman & T. I. Eldho	Identifying Contaminant Sources In Groundwater Using Kriging Based Surrogate Model And Particle Swarm Optimization
5.	198	Ankita P. Dadhich, Pran N. Dadhich & Rohit Goyal	Groundwater Quality Evaluation For Drinking And Agriculture Use In Phagi Block, Jaipur District
6.	251	Asha Farsana M, Sajikumar N & Subaida E.A	Effect of Heterogeneity and Anisotropy on Enhanced Spreading in Porous Media during Engineered Injection and Extraction
7.	320	K.R.Athul Krishna & D.Karmakar	Gravity Wave Dissipation due to Multiple Porous Structures

8.	322	Khansa Abdullah & D.Karmakar	Dissipation of Gravity Waves due to Submerged Porous Plate and Bottom Standing Porous Structure
9.	369	Abhinash Sahoo, Niharika Patel, Siddhartha Paul, Sandeep Samantaray & Pratapneni Bharat	Prophecy of Ground Water using Hybrid ANFIS-FFA Approaches at Kalahandi Watershed, India
10.	495	Muskula Sai Bargav Reddy, Sanat Nalini Sahoo	Modelling and management of Salt Water Intrusion in Coastal aquifers using SEAWAT: A Review

**DAY 3**  
**28<sup>th</sup> March 2021 (Sunday)**

**FIFTH TECHNICAL SESSION**  
**PARALLEL SESSION 1/SERVER 1**  
**Time: 01:20 PM TO 03:50 PM**  
**Theme: Hydraulics and Hydrologic Modelling**  
**PARALLEL SESSION PRESENTATIONS**

**Session Chairpersons: 1-Dr. Ashutosh Sharma, IIT Roorkee, 2- Shri. S. G. Manjunatha,  
CWPRS Pune**

<b>SL. NO.</b>	<b>PAPER ID</b>	<b>AUTHORS</b>	<b>TITLE</b>
1.	013	Ankit Balvanshi & H.L. Tiwari	Effect of Climate Change on Future Reference Evapotranspiration (ET <sub>0</sub> ) in Vidisha district of Madhya Pradesh
2.	018	Abhishek Verma, H.L. Tiwari, Ravi Galkatel & Ankit Balvanshi	Simulation of Rainfall Runoff using HEC-HMS Model for Bah River Basin of Vidisha Region in Central India
3.	231	J. A. Shimpi, Dr. J. D. Agrawal	Shoreline Change Analysis Behind South Breakwater of Paradip Port By DSAS Technique
4.	278	Tapasranjan Das, Prof. Arup Kumar Sarma	Estimation of Rainfall Erosivity Factor of Guwahati with High Temporal Resolution Rainfall Data
5.	379	Subhasmita Sethi, Ratnakar Swain, Bibhuti Bhushan Mukharjee	Simulation of Rainfall-Runoff Process using HEC - HMS
6.	432	V. M. Rana, Prof. (Dr.) H M Patel	Simulation of Water Level Oscillations in Orifice Type Surge Tank under Sudden Changes in Turbine Inlet Discharge
7.	433	Radhika Solanki, Prof. (Dr.) H M Patel	Simulation of Ajwa Reservoir using HEC-ResSim

8.	441	Ravi Patel, Geeta Joshi, Gaurang Joshi	Computation of Hydro-Electric Power Generation on Canal Falls at Vadodara Branch Canal
9.	498	Bedank Agrawal, Kishanjit Kumar Khatua	Case Study on Kaddam Dam
10.	502	Bedank Agrawal, K. K. Khatua	Dam Break Analysis Of Hirakud Dam Using HEC-RAS

## PARALLEL SESSION 2/SERVER 2

**Time: 01:20 PM TO 03:50 PM**

**Theme: CFD/Numerical Modelling**

### PARALLEL SESSION PRESENTATIONS

**Session Chairpersons: 1- Dr. Basavaraju Manu, NITK Surathkal, 2- Dr. Arpan Pradhan,  
Christ University, Bangalore**

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	004	H. L. Tiwari & Kamal Singh	Experimental Study of Dam Pipe Outlet Stilling Basin Models Using Two Baffle Walls
2.	021	Indrashis Saha, Tathagata Mukherjee, Ankit Saha & Richa Pandey	Aerodynamic Study of an Ahmed Body with the help of CFD Simulation
3.	032	Biswal, S. K., and Khanam, N	Numerical investigation of flow around a circular pier in channel confluence with unequal bed level
4.	056	Rukaiya Kausher, Anand Kumar Sinha	The Significance of Numerical Simulations for Hydrogeological and Groundwater Flow Modelling studies in the mining areas
5.	192	Indrashis Saha, Tathagata Mukherjee, Richa Pandey	Comparative Study of Mixture model and Eulerian Model used in Hydrocyclone with the help of CFD Simulation
6.	196	Javed Alam, Mohd. Muzzammil, Mohd. Kafi and Misbah ul Haque	Application of FLUENT Software in Determination of Permeability of Soil
7.	468	N. Vivekanandan	Comparison of Estimators of Weibull Distribution for Low-flow Frequency Analysis
8.	488	Manish Kumar	Real Time Decision Support System (RTDSS) using MIKE software package for operational management

			of reservoirs - A case study of Bhakra and Pong reservoirs
9.	491	Amit Pawar, RuchiKhare	Design of Multistage Centrifugal Pump and Performance Analysis of Single stage using CFD
10.	503	Subodh Shrivastava. S. N. Sahoo	Seepage and stability analysis of earthen dam in slow and rapid drawdown condition.
11.	504	S. Pandey, A. K. Laharia, S. K. Sharma, A. Shrivastava	State of Art: Hydraulic design of storm water drainage system of Nuclear Power Plant using 2-D numerical simulation

### PARALLEL SESSION 3/SERVER 3

Time: 01:20 PM TO 03:50 PM

Theme: Hydraulics, Hydrology and Water Quality Modelling

#### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. Rajib Bhattacharya, IIT Guwahati, 2- Dr. Krishna Kishore Osuri, NIT Rourkela

SL. NO.	PAPER ID	AUTHORS	TITLE
1.	031	Shubham Agrahari and M C Deo	Evaluation of Design Wind based on Projected Cyclonic Conditions
2.	033	Shantaram Patil, Shyam Shukla & Ravindra Birajdar	Head loss prediction at the water tunnel and shaft junction
3.	052	Venkateswarlu Turuganti, Abdul Hannan, Maitreyee Talnikar & Jagadeesh Anmala	Significance Of Classification And Regression Tree (Cart) Models In The Prediction Of River Water Quality
4.	064	B.Bharani Baanu, Dr. K.S. Jinesh Babu	IoT enabled greywater management
5.	099	Gaurav Misuriya, T. I. Eldho	Effect of flow depth and velocity on the local scouring around rectangular bridge pier on gravel bed
6.	109	Aiendrila Dey, Renji Remesan	Impact of choice of different runoff and river routing schemes in JULES land surface model: A case study from Damodar river basin
7.	135	Ayilobeni Kikon, Paresh Chandra Deka	Trend Analysis of Meteorological drought for India region.
8.	252	Sherjah P. Yusuf Ali, N. Sajikumar	Indication about the bio-optical status of a water body from its spectrum measured by Sentinel 2 MSI
9.	347	Nayankumar Soni, Dr. Sanjay Dhiman	Salinity ingress Studies in Coastal Stretch Of Bhavnagar to Una, Gujarat, India
10.	508	Ramsha Khan, Abhishek Saxena	Probabilistic Human Health Risk Assessment of heavy metals in River Gomti in Lucknow city, India

## PARALLEL SESSION 4/SERVER 4

Time: 01:20 PM TO 03:35 PM

Theme: Hydrometeorology

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Prof. Bimlesh Kumar, IIT Guwahati, 2- Prof. D. G. Regulwar, GCOE Aurangabad

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1	141	Arya Sajeew, Subrahmanya Kundapura	Stream flow and Hydrological Drought Trend analysis and forecasting
2	285	Saranya P. S, Gopakumar R, Adarsh S	Event Based Hydrologic Modelling of a Data-Sparse Micro-watershed: Case Study of Thrissur Zoological Park
3	296	P. Singh, V. K. Bind, B. K. Samtani	Prediction of the discharge carrying capacity of lower Tapi River with the help of HEC-RAS 1-D hydrodynamic modelling
4	323	Merlin Rachel Varghese, D. Karmakar	Wave Transformation Due To Composite Breakwater System
5	328	Abhishek G. Karaseeri, D. Karmakar	Gravity Wave Trapping By Stratified Porous Structures Combined With Submerged Porous Plate
6	349	Harsh Ganapathi, Preethi Vasudevan	Investigation of Variability of Meteorological Dry/Wet Conditions and its Implications in Chennai, India during 1960–2020
7	354	Dr. Ray Singh Meena, Prof. Ramakar Jha	Development of Soil Water Retention Curve in Lower Kosi River Basin, India using Transfer Function
8	378	Pandu Narayana and Varija Kumble	Rainfall Interception from the Dual Canopy of Coffee Plantation in the Western Ghats
9	403	Nikhil Kumar, Manish Kumar Goyal	Evaluation of precipitation-recharge relationship and groundwater resilience of catchments in Madhya Pradesh

10.	446	Amandeep Choudhary, Bhabani Shankar Das	Review on scour depth modelling of bridge pier
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## PARALLEL SESSION 5/SERVER 5

Time: 01:20 PM TO 03:50 PM

Theme: Hydrometeorology, Water Resources Management and Soft Computing

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1-Prof. D. N. Rath, Thapar University, Patiala, 2- Dr. Bhabani Shankar Das, NIT Patna

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1	144	Siva Krishna Reddy, Venu Chandra	Application of ANNs to scour prediction around non-uniform piers
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3	412	Shivam Singh, Manish Kumar Goyal	Frequency- Duration Assessment of Atmospheric Rivers at Global scale
4	418	Sweety Rajput, Dr. B.S Das, Dr. A. K. Sharma	A review on study of hydrodynamics and sustainable model of raceway pond
5	431	Amit Chavada, Dr. H. M. Patel	Dam Break Analysis Using HEC-RAS: A Case study of Kadana dam
6	437	Raza, M.M, Javed Alam and Mohd Muzzammil	Efficacy of Nano particles of Flyash on its permeability
7	486	Shalini, Bhabani Shankar Das, Roshni T	Scour Depth Modelling Using Gene Expression Programming
8	485	Birat Raut, Pawan Kumar Shrestha	Analysis of Squeezing Problem in tunnel: A Case Study of Middle Modi Hydroelectric Project, Parbat, Nepal
9	487	Poli Bhavani Prakash, Pragyan Das, Awadhesh Kumar	Research on the Impact of Heavy Metals on Surface Water Quality of Brahmani River
10.	501	Naman, Kanhu Charan Patra	Application of Multi Gene Genetic Programming for Prediction of Discharge in Open Channels with Vegetation

## PARALLEL SESSION 6/SERVER 6

Time: 01:20 PM TO 03:50 PM

Theme: Hydrodynamics and River Engineering

### PARALLEL SESSION PRESENTATIONS

Session Chairpersons: 1- Dr. Mahesh Patel, NIT Jalandhar, 2- Dr. Anurag Sharma, NIT Rourkela

SL. NO.	PAPER ID	AUTHORS	TITLE
1	063	Kamalini Devi, Bhabani Shankar Das, Jnana Ranjan Khuntia, Gutha Ruthwikesh Reddy, Annepu Laxmi Prasad	Interlinking Prospect of Godavari River with Krishna River
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6	276	Jagpreet Singh Kamboj, Sahibpreet Singh, Mahesh Patel	Wastewater Management through Water Drainage System: A Case Study
7	281	M. Sayan, P.V. Timbadiya	Hydrodynamic Modelling of Upper Tapi River, India
8	293	G. Yatirajulu and P. V. Timbadiya	Simulation of Channel Bed Level Variation And Its Experimental Validation

9	507	Ratnakar Swain	Impact of deforestation and urbanization on extreme temperature and humidity over Brahmani River Basin
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THEME – III	Flood Forecasting and Management
THEME – IV	Groundwater Modeling and Management
THEME – V	Hydraulic Structures and Hydropower Engineering
THEME – VI	Hydrologic & Hydraulic Modeling
THEME – VII	Hydrometeorology
THEME – VIII	Hydrometeorology, Water Resources Management and Soft Computing
THEME – IX	Hydraulics, Hydrology and Water Quality Modelling
THEME – X	Impact of Climate Change on Water Resources
THEME – XI	River Hydraulics
THEME – XII	River and Coastal Engineering
THEME – XIII	RS & GIS Application for Water Resources Management
THEME – XIV	Sediment Transport
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9.	Historical and Future Sea Level Rise at Major Indian Ports <i>Priyen Somaiya, Raghavendra G. Patil and M C Deo</i>	07
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**THEME – I**  
**COASTAL & OCEAN ENGINEERING**



## FACTORS AFFECTING THE VESSEL TURNAROUND TIME IN A SEAPORT

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### Abstract

Turnaround time in a seaport exhibits the capability and ability of a port in providing efficient services. Ship turnaround time is one of the most significant Port performance indicators. This is the total time, spent by the vessel in port, during a given call. It is the sum of waiting time, plus berthing time, plus service time (i.e. ship's time at berth), plus sailing delay. Indian ports play a crucial role in trade and economy, as 95 % of merchandise trade is handled by ports. However, port turnaround time remains key problem. It is significantly slower than across peer ports in other developing countries, being several times higher than for ports in China, Singapore and Malaysia. To reduce the turnaround time of a vessel in a seaport, the port processes are to be streamlined and capacity augmented. This paper is aimed at identifying the factors that are responsible for turnaround time of vessels at the port. This study is motivated by the rapid development in Indian port sector, in providing efficient and effective services and high port productivity, with the aim to achieve optimum port performance. The turnaround time is a function of port operations and port facilities. As currently it is not possible to determine significant factor(s) that influence port performance, in terms of turnaround time. The primary data of vessel arrival/departure in New Mangalore Port trust recorded at VTMS are used. This study is very useful in decision making of port Authorities as well as ship operators in any given budget or resource input, the output results in time minimization and it is possible to tackle all the delay causing factors by the port Management in providing efficient and effective services and high port productivity, with the aim to achieve optimum port performance.

**Keywords:** Port, Performance, Indicators, turnaround time, Quality of service, port facilities, optimization, Port management

## Diffraction Studies Pertaining to Functional Design of Breakwaters-A Case Study of Gangavaram Port, East Coast of India

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### Abstract

Development of port requires the selection of proper alignment, a significant step in the functional design of breakwater which in turn can be decided through diffraction studies. Towards this objective, a model has been developed for the determination of diffraction coefficients for given environmental settings. The model has been applied for the analysis of the diffraction pattern for coastal waters off Gangavaram located in the East Coast of India (17° 37' 30" N latitude, 83° 14' East longitude) using the available data of physical, meteorological and topographical parameters. The outcome of the study enabled us to suggest a suitable layout of breakwater for the selected port location. The simulated diffraction coefficients obtained through model developed with an approach



angle 60° with respect to wave direction have been found to be varying between 0.05 and 0.67 covering 20 Sq. km area, which is indicative of relatively stable and calm water in the leeward side of break water independent of seasons, for the data considered.

**Keywords:** Breakwater alignment; Functional design; Diffraction coefficient; Approach angle

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Paper ID – 81

## Numerical Model Studies to Assess the Morphological Changes Due to Coastal Front Development- A Case Study

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### Abstract

Modernization of ports and port-led development will lead to India's economic growth. The Industrial clusters and hinterland and efficient evacuation systems through road, rail, inland and coastal waterways resulting in Ports becoming the drivers of economic activity in coastal areas. Along the East Coast of India in Andhra Pradesh State series of passenger jetties are proposed under Sagarmala project to promote tourism in the state which in turn would generate revenue and employment. Safe berthing and maneuvering facilities for passenger cruise require proper alignment of jetty and approach channel. The sedimentation in and around the development area should be optimal so that the project is techno-economic viable and should be conducive to all weather operations. Optimization of layout of a harbour in an inlet on East Coast of India which is generally characterized by steep bed slopes, high magnitude of littoral drift and severe wave climate with rivers debouching sediments into Bay of Bengal, is an engineering challenge. The present paper describes a case study in which mathematical model studies was carried out by using MIKE 21 software to study hydrodynamics and morphological changes in the vicinity of proposed passenger jetty. The model limits considered for the studies about 2 km on either side of the Gostani River mouth at Bheemunipatnam and extended to a depth -21.0 m CD in the offshore. The study include simulation of hydrodynamics for different tidal conditions for the existing condition to calibrate with the field data and then the calibrated model is run for the proposed conditions to find out the changes in the hydrodynamics and morphology in and around the proposed passenger jetty.

**Keywords:** Hydrodynamics, Morphology, approach channel, Passenger jetty.

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## INNOVATIVE SOFT OPTION OF COASTAL PROTECTION BY FLOATING SEAWEED FARM - A REVIEW

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### Abstract

Increased human activity along the coastal zone increased the vulnerability and altered the equilibrium of the coast for many years; it also accelerated the innovation in breakwater design for improvised efficiency and less destructive to the environment. Hard solutions to coastal protection are heavy structures, deployed where sensitive areas are to be protected against strong waves. A soft solution includes converting natural features as a buffer zone. It can be used in a mild wave environment or in the area requiring partial tranquility conditions. Once people started realizing the mangrove forest acted as a protective barrier against the destructive 2004 Indian Ocean tsunami and saved several villages, there was more curiosity started to build-up towards natural barriers such as mangrove forest, coral reef, seagrass meadow for coastal protection. Seaweeds are naturally occurring macroalgae living in the surf zone and they are farmed on a large scale throughout the world adopting the off-bottom method, unlike other natural barriers that are bottom fixed. Evaluating their effect on hydrodynamics is essential to understand the consequences of the farm in the coastal protection. In this paper research related to seaweed, their farming and their applicability for coastal erosion mitigation is reviewed. The current status of seaweed farming in India is also addressed.

**Keywords:** *Coastal protection, coastal vegetation; kelp farm; seaweed farming.*

## Study of sediment behaviour along the Mangalore coast through granulometric studies

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### Abstract

Studying sediment behavior and identifying sediment transport pattern is essential in coastal engineering and management projects. In the present study, grain size characteristics of the foreshore beach sand along the Mangalore Coast, West Coast of India, were examined to study the sediment behaviour along the coast. Mode of sediment transportation and deposition of sediments can be inferred from the grain size analysis. Sediment movement trends can be identified from grain size statistical parameters using the technique Sediment Trend Analysis (STA). In STA, the spatial variation of grain size parameters (mean grain size, sorting and skewness) occurring during the sediment transport process from sedimentary source to deposit is analyzed to define the sediment transport path. The grain size statistical parameters show that the foreshore beaches are significantly composed of fine sand (31%) and medium sand (52%). The grains are slightly coarser (0.719  $\phi$ ) on the southern side of the study area and finer (2.185  $\phi$ ) towards the northern side. Sediments are very well sorted (0.312  $\phi$ ) to moderately sorted (0.991  $\phi$ ) along the beach dominated by moderately well sorted (66%) samples. Sand samples



were identified as positive (48%) to negative (52%) skewed with platykurtic, mesokurtic and leptokurtic characters. The average skewness of the beach is obtained as symmetrical, indicative of an environment having balanced erosion and deposition. The sediment transport along the coast was studied for the months receiving minimum rainfall, December 2019 and January 2020. Study shows that the net littoral drift along the coast during this period is very less as sediment trends are obtained in both directions.

**Keywords:** *Sediment transport; Sediment Trend Analysis; Grain size statistical parameters; Littoral drift.*

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Paper ID – 114

## **Study of shoreline change along the Kasaragod district in Kerala, West Coast of India**

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### **Abstract**

Study of the effects of oceanographic processes such as erosion and accretion are very important to understand the nature of a coast. Coastlines exhibit a wide range of changes depending on the interactions of tide and wave energy, sediment supply and more importantly human intervention. Generally, the coastline of Kasaragod district (Kerala state) along the west coast of India is dominated by both erosion and a stable condition. In view of this, the present study has been carried out to calculate the long term shoreline change rates along the Kasaragod coast using delineated Landsat images obtained during 1990-2020, at 5-year intervals and to identify the critical erosion zones. Transects were cast at 500-m intervals perpendicular to the coast and long-term shoreline change rates were calculated at each transect based on a linear regression method using Digital Shoreline Analysis System (DSAS), which is an extension of the ArcGIS software. The long-term analysis results indicate an average shoreline change rate of  $-0.21$  m/year along the study area coast. Further, the rates obtained were classified as stable ( $-1$  to  $+1$  m/year), erosion (more than  $1$  m/year) and accretion (more than  $1$  m/year). Based on this classification, about 25.43% of the coast is eroding, 66.48% is stable and the remaining 8.09% is accreting in nature.

**Keywords:** *Shoreline change; DSAS; Stable coast; Erosion; Accretion*

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Paper ID – 129

## **Ascertaining the effect of Mesh resolution in MIKE 21 Spectral Wave model results**

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### **Abstract**

Mesh resolution is one of the main parameters to be considered while setting up a numerical model as it may influence the model results. A flexible mesh approach is used in numerical modeling using MIKE 21 Spectral Wave (SW) module. The effect of different mesh resolutions in numerical modeling results of MIKE 21 Spectral Wave (SW) module is investigated in this paper. The wave transformation model for deep water to shallow waters



was modeled using MIKE 21 SW. The Thrikunnapuzha coastline in Alappuzha district in Kerala was selected for setting up the model. The model simulations were carried out with 10 different mesh resolutions ranging from 50m to 500m to study the effect on output wave parameters like wave height and Time period. The analysis of results reveals that the mesh resolution did not have considerable effect in the output wave parameters. The inference obtained from this study would provide a basic idea regarding choosing an appropriate mesh resolution to setup an optimized MIKE 21 SW model which will take less computational time and memory without compromising the accuracy of the output results.

**Keywords:** Numerical model, MIKE 21, Spectral Wave model, Mesh resolution.

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Paper ID - 131

## Mathematical modelling to ascertain the effect of Groyne field on Beach Fill stability

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### Abstract

The project work involves setting up of mathematical models using MIKE 21 FM software (Integrated coupled models). The study area taken into consideration is the Visakhapatnam northern coastline adjacent to Visakhapatnam port. The stretch up to Waltair point comprising of Ramakrishna beach on North side of Visakhapatnam Outer harbour is the main study area. In order to study the morphological aspects, coupled model comprising of three modules viz; Hydrodynamic (HD), Spectral Wave (SW) and Sediment transport (ST) was setup. Model simulations were carried out to arrive at appropriate hard measures like groyne field, so as to improve the stability of a conceptual beach fill at the Visakhapatnam coast. The model was setup to represent the South-West monsoon season which is the predominant season for Visakhapatnam coast. A conceptual beach fill was modelled for the study area. The different model simulation runs were carried out for beach fill and beach fill with groynes. The model output parameters like Sediment Transport rate, Wave height parameters and Wave run-up are analyzed. Useful inferences about effect of groynes on the beachfill were derived with systematic post-processing of the model results. This in-turn is useful to evolve suitable coastal protection measures incorporating both soft and hard measures to address the issues like 'coastline stability' which is very essential for 'littoral drift' prone east coast of India.

**Keywords:** MIKE 21 FM, Coupled Model, Beach fill, Groyne field, Waves, Sediment Transport.

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Paper ID - 184

## Historical and Future Sea Level Rise at Major Indian Ports

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### Abstract

Considering that India has a large port infrastructure spread across its 7000 km of coastline it becomes necessary to estimate the sea level rise (SLR) likely to be impacted by the effect of climate change at its major port locations. Although a good number of studies assessing historical India-specific data exist, those comparing them with rigorous future projections from the general circulation models are few in number and owing to various uncertainties in the predictions involved they need further confirmation. This study is aimed in this direction and it provides an evaluation of SLR at 11 major Indian ports as per historical tide gauge observations as well as from



satellite-based measurements. Such SLR estimates are further compared with SLR values projected into the future and up to the end of the present century as per a medium global warming scenario called representative concentration pathway (RCP) – 4.5. The projected SLR data are based on an existing algorithm that scales the global SLR with the local one empirically. The results show that the recently collected satellite data are indicative of an accelerated growth of SLR than the one estimated from the past long-term tide gauge data; however, both these rates are likely to be much exceeded in future and could go beyond 5 mm/year at some major ports.

**Keywords:** *Sea Level Rise; Climate Change; Major Ports*

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Paper ID – 190

## STABILIZATION OF INLET AND RESTORATION OF RIVER MOUTH IN PUTHIYANGADI

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### Abstract

The alongshore sand movement which occurs in both, northward and southward directions, depending upon the wave conditions, is mainly responsible for choking the mouth of estuaries / rivers either partially or completely depending upon the river discharge conditions. The Proposed mini fishery harbour site (12<sup>o</sup> 01' 08''N and 75<sup>o</sup> 14' 05''E) is located at Puthiyangadi, Kerala on the west coast of India. This development area is about 1.10 km south from the Perumba river mouth. This river mouth is used by the fishermen but it is unstable in nature due to the prevailing drift conditions. Net drift in this area is towards south which partially blocks the river mouth causing large inconvenience to fishermen for the movement of their boats. In this regard, the Project Authority suggested one training work of about length 600m on the southern side of river mouth. The hydrodynamic and sedimentation studies carried out at CWPRS indicated that the proposed layout would block the southward drift causing huge sedimentation at the river mouth. Further, a modified layout was recommended consisting of two converging training works (breakwaters) on either bank of the river mouth with total length of about 560m, about 40 m less than the proposed length of single training work. It was also observed that with the modified layout, the velocity at the river mouth would increase by about 45% which would help in flushing the sediments. It was found that with the proposed layout with two training works on either bank of the river mouth, the suitable hydraulic conditions at the entrance of river would be maintained and the mouth would keep open throughout the year.

**Keywords:** *Hydrodynamics, Siltation, Tidal current, wave induced currents and river mouth*

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Paper ID – 194

## RESTORATION OF TIDAL CREEK INLET FOR NAVIGATION USING PILE JETTY - A CASE STUDY

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### Abstract

In this study, a depth-averaged numerical model has been developed using MIKE 21 FM software to study tidal circulation in creek inlet located at Satpati, Maharashtra in West coast of India. The creek area is facing sedimentation problem due to meagre and irregular tidal circulation in the inlet. Numerical experiments of tidal circulation are carried out for probable restoration of the creek inlet with partial replacement of the existing 170 m long solid passenger jetty on the south bank of the river with the semi-piled jetty having 18 numbers of piles each of 1 m diameter. The alignment of the proposed jetty is modified to streamline flow conditions near the jetty head for making ferries more suitable for berthing at the jetty. Computed results are validated with field observations. Model results in experimental scenarios indicated that flow conditions in the creek channel near the piled jetty have been improved with maximum flow velocity to be of the order of 0.3 m/s. As no freshwater discharge conditions have been considered, the results are appropriate for dry season only.

**Keywords:** Fishing harbour, Tide, wave induced currents, creek inlet and navigational channel.

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Paper ID – 200

## Estimation of Wave Loads on Deck Structures at Indian Ports in a Changing Climate

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### Abstract

Coastal structural damage has been a serious issue in past decades due to changes in various ocean environmental parameters and increased frequency of extreme events. The present study focuses on the estimation of wave loads on typical coastal deck structures at major Indian ports in a changing climate scenario. The percentage changes in wave height and sea level rise (SLR) due to climate change at the end of the design life of the structures were considered from the recent past studies. The vertical and horizontal impact forces on deck structures are computed using suitable method suggested by Xu (2015). The effect of climate change has been investigated by applying the future ocean climate characteristics, such as future wave height conditions and sea level rise scenarios. The computed impact forces are compared with the current ocean state impact force estimation to assess the percentage change due to climate change. The impact forces are estimated on the deck structures located at different airgaps that may arise under the rising sea level condition. Overall, the study concluded that there is a significant change in impact forces on coastal deck structures due to climate change, where the percentage change varies with varying airgaps and port location. The vertical force is increasing for smaller air gaps only whereas horizontal force increases for increasing air gaps. Thus, it is necessary to consider the increasing impact forces for design of future deck structures at port facilities and along coastal locations.

**Keywords:** Wave Load; Coastal deck; Ports; Climate change; Sea level rise; Extreme events; Airgap

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## Effect of wave steepness on wave overtopping discharge of an emerged quarter-circle breakwater

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### Abstract

A breakwater is a structure that is commonly used in ports and harbour to protect from the onslaught of perennially hitting ocean waves. There are different types of breakwater structures developed so far by various researchers, in which Quarter circle breakwater (QBW) is also one such innovation. In the present investigations, the physical model studies are conducted on emerged non-perforated and sea-side perforated QBW with varying percentages of perforation using the wave flume available in the Marine Structures Laboratory of Water Resources and Ocean Engineering Department, National Institute of Technology Karnataka, Surathkal, India. A model scale of 1:30 is used, along with a range wave climate of the Mangalore coast in the Karnataka state of India. The wave overtopping discharge is measured by varying wave characteristics & depth of water(d). The data gathered is analyzed by plotting non-dimensional graphs depicting the variation of  $q/gH_iT$  with varying percentages of perforations (p) for values of wave steepness ( $H_i/gT^2$ ). It is observed that the dimensionless wave overtopping discharge ( $q/gH_iT$ ) increases with an increase in wave steepness ( $H_i/gT^2$ ). Also, it is found that an increase in the percentage of perforation, wave overtopping discharge ( $q/gH_iT$ ) is decreased.

**Keywords:** Quarter circle breakwater, incident wave steepness, wave overtopping discharge, percentage of perforations.

## Numerical Modelling for Wave Transformation along the Ratnagiri Coast-Case Study

Pranav Vaishampayan<sup>1</sup>, Amol S. Borkar<sup>2</sup>, Varun Khengare<sup>3</sup>, Ketan Jadhav<sup>4</sup>, Abhishek Deshmukh<sup>5</sup>, Prof. Shilpi Bhuinyan<sup>6</sup>, Dr. Prabhat Chandra<sup>7</sup>

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### Abstract

Wave transformation from deep shore to the near shore is a composite process. Generally, near shore wave climate along the coast is not readily available. The present investigation covers obtaining the near shore wave climate near Bhagwati breakwater close to Ratnagiri coast along West coast of India by using the Numerical MIKE-21 SW (Spectral Wave) model. The maximum tidal range at the site is about 2.3 m and the site is exposed to waves from SW to NW directions. The deep offshore data as obtained from Indian Meteorological Department (IMD) was utilized to derive the nearshore wave conditions at the Bhagwati Breakwater at (-)10 m depth. The model results were also compared with the measured wave data at (-)15 m near site of Bhagwati breakwater. The results from the MIKE-21 Spectral wave model studies show that the predominant waves after



transformation from deep to near fall between the sector 225° N to 315° N i.e. the site is exposed to predominant waves from SW, WSW, West, WNW, and NW directions. The significant waves of height of about 2.5m waves reach at (-)10 m depth. The analysis of the statistical parameters of waves and wave direction shows a reasonably good match between the model and the observed data except some minor difference in the angles. The studies will be very useful for providing input conditions for future port development scheme at Bhagwati bunder for ascertaining the detailed wave tranquility conditions.

**Keywords:** *Wave transformation; offshore wave data; near-shore wave data; numerical modelling.*

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Paper ID – 243

## **Effect of Marine Growth on Wave Loading on Small Diameter Tubular Structural Members**

**Sarath Suresh<sup>1</sup>, Rameeza Moideen<sup>2</sup>, Manasa Ranjan Behera<sup>3</sup>**

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### **Abstract**

Offshore structural installations are the backbone of key industries such as Oil & Gas and Wind Energy. These structures are subjected to harsh environmental loads and conditions that are not encountered by any land-based structures. Marine growth resulting in excess hydrodynamics loading is the major concern for all these structures. These marine growths, typically classified as hard and soft growth, alter various aspects of the structural member such as its thickness and surface roughness. The variation in these parameters can drastically affect the wave forces acting upon them, causing loading that was not intended or expected during the design phase. The present study aims at computing the additional wave loading that occurs on an offshore structural member, particularly small diameter tubular members, due to the presence of naturally occurring marine growth. To estimate the effect of marine growth, a typical structural member is divided into user-specified number of zones with varying degrees of growth thicknesses. A GUI tool is developed based on the modified Morison's equation using MATLAB that calculates the wave forces on these structural members. A detailed investigation is carried out by varying different parameters affecting the wave force due to marine growth such as member diameter, varying marine growth thickness along depth and member inclination. The study concludes that the presence of marine growth causes an accompanying increase in the wave loading, with a sample case of a 70 mm thick uniform marine growth yielding a ~26% increase in the wave loading. The variation in member parameters such as its inclination and diameter also caused corresponding changes in the wave loading, the effect of each being tabulated and explained as part of the study. Thus, the study helps to comprehend the magnitude of the change in wave loading due to marine growth and the need for its accurate estimation during the design phase of the structure.

**Keywords:** *Offshore Structure; Marine Growth; Wave Loading; Morison's Equation, GUI*

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Paper ID – 261

## Performance evaluation of detached breakwater in Poonthura coast using Boussinesq wave approach

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### Abstract

Poonthura coast located at the southwest part in Kerala, has been undergoing severe chronic erosion. A series of detached breakwater was proposed to prevent erosion at Poonthura coast, Trivandrum. This study analyses the hydrodynamic performance of these artificial reefs using an interactive coastal wave simulation tool, Celeris. It is a hybrid finite volume-finite difference based code that solves the extended Boussinesq equation for modeling the near shore wave transformation. The proposed configuration of structure at Poonthura coast includes five detached reef at a distance of 125m from the shore with the crest of the structure placed at charted datum. The design height of reef is 6m with a length of 100m and a spacing of 50m between individual reefs. The model is setup with a domain extending 9.5km along the coast and 11 km across with a structured mesh of size 5m. The boundary along the east is considered as open and forced by input wave parameters and the lateral boundaries were chosen to reduce the reflections into the domain. The average significant wave heights were found from the wave data collected by NIOT at 50m depth during 2018. The model was run with and without the structure and results were compared for changes in wave height. The differences in wave heights with and without reef were quantified. With most of the wave energy getting reflected or diffracted due to the reefs, only a small portion of wave energy reaches the protected coastal stretch. It was observed that most of the waves propagating through the 50m gaps were laterally spreading, resulting in dissipation of wave energy through diffraction. The relation of wave height and alongshore transport suggest a reduction in the erosion and hence the proposed structure will satisfy its intended purpose.

**Keywords:** Detached breakwater; Celeris; Open source Boussinesq wave model; Poonthura

Paper ID – 383

## Effect of Porous Baffle on Sloshing Dynamics Placed at $L/2$ Location in a Sway Excited Rectangular Tank

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### Abstract

The large liquid movement in tanks creates highly localized impact pressure on tank walls and also displays a violent disturbance in the fluid. Hence, this highly nonlinear nature of the problem is the greatest hindrance in solving such a problem analytically and even computationally. Ship structures are likely subjected to impact pressure actions arising from sloshing, slamming, and green seas while in service. The accelerations arising from the motions of a ship in a seaway produce sloshing loads, that is, inertial reactions, on partially filled liquid cargo tank structures of the ship. Motions of liquid cargo vessels such as oil tankers often produce severe sloshing loads. Tanks of moored floating, production, storage, and offloading units are continuously loaded and unloaded, and sloshing in the tanks is unavoidable. Because of this difficulty, an experimental study has been carried out to assess the sloshing oscillation expected on the sidewalls of the tank. A liquid fill level with an aspect ratio ( $h_s/l$ ,



where  $h_s$  is static liquid depth,  $l$  is tank length) of 0.1625 and 0.325 is considered which corresponds to 25% and 50% liquid fill level. Because of suppressing sloshing oscillation and baffle wall configurations with different porosities (4.4%, 6.8%, and 9.2%) by placing baffle at a distance of  $L/2$  in a rectangular tank are studied. The sloshing tank of model scale 1:43 is fitted into the horizontal shake table.

**Keywords:** Shake table; sloshing tank; Porous baffles.

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Paper ID – 416

## Behaviour of Rubberized concrete when subjected to exposure along coastal zone

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### Abstract

It has always been a challenge to maintain and protect the structures in and around the coastal area. Concrete which is one of the mostly used material for construction has many limitations when exposed to coastal environment. Rubberized concrete is continuously evolving as a sustainable concrete by minimizing the use of river sand in concrete and utilizing scrap tires in place of fine and coarse aggregate. In this study, behavior of rubberized concrete was studied in coastal environment to assess its suitability for construction along coastal area. Rubberized concrete (M30) was made by utilizing waste scrap tires in the form of fine aggregate, replacing river sand by 7.5%. This optimum percentage was taken after the result of strength studies which showed that strength decreased below the minimum strength criteria when crumb rubber percentage was increased beyond 7.5%. The concrete samples were then subjected to curing for 28 days, and also some samples were cured up to 150 days along the coast of Visakhapatnam, Andhra Pradesh. Experimental tests like Compressive strength, split tensile strength, water absorption, sorptivity, electrical resistivity and chloride ingress test were conducted. The test results indicated that water absorption, sorptivity, electrical resistivity and chloride ingress tests of rubberized concrete were comparatively less than conventional M30 mix subjected to same exposure condition. This gives an idea that rubberized concrete can perform better and give better durability in coastal environment. The strength result obtained were comparatively less than normal M30 mix but were well above the minimum strength criteria.

**Keywords:** Rubberized concrete; Coastal environment; Sorptivity; electrical resistivity.

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Paper ID – 426

## Forecasting of Natural Disasters, A Case Study on Coastal Part of Odisha

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### Abstract

India has been vulnerable to natural hazards particularly floods, cyclones, droughts, extreme heatwaves, landslides, and tsunamis on account of its change in the climate. According to the Global Climate Risk Index report 2019, India is the 14th most vulnerable country in the world due to extreme weather-related events. In



India, it is found that these disasters frequently hit the coastal belt, so here an attempt is done to estimate the future magnitude of the disasters at the coastal belt of Odisha. After the industrial revolution the data indicates that the frequency as well as magnitude of all-natural disasters increased. The damage due to natural disasters affects people and the environment in all directions. It is hard to predict the occurring of natural disasters but with the latest forecasting techniques by machine learning algorithms attempt can be done to forecast the magnitude of the disasters. It is time to forecast the magnitudes of natural hazards to mitigate the damage to infrastructure, economy, and fatalities. Statistical analysis can be done with the historical natural disaster data to find the trend and correlation among the climatic parameters concerning time and changing land use land cover. The result of this study would help the local authorities for better planning and management of disasters and take appropriate emergency action plans to reduce the damage in the particular area.

**Keywords:** *Natural disasters and management, Machine learning algorithms, Statistical analysis*

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Paper ID – 470

## **MATHEMATICAL MODELLING AND SIMULATION OF OCEAN DISPOSAL OF HARBOUR DREDGED MATERIALS**

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### **Abstract**

Sedimentation is a major problem for coastal management authorities to maintain the depth for smooth movement of large vessels in and around the ports. Maintenance dredging is required periodically to maintain the desired depths in navigational channel and inside the port. Uncontrolled dumping of the dredged materials might create negative impacts on the living marine resources. Selection of disposal sites in open sea is one of the most important steps of dredge material management process to minimize the possible negative impacts on navigational channels, ports, harbours and other coastal structures. Two-dimensional mathematical model studies undertaken for identification of disposal grounds of the dredged material due to expansion of captive jetty facilities for an existing port located at about 22 km away from the mouth of Dharamtar creek on the right bank of Amba River at Dolvi in Raigad district of Maharashtra. Hydrodynamic and dispersion model studies using MIKE 21 FM software were carried out to assess the changes likely to occur in flow fields and identification of disposal ground in open sea for disposal of dredged material from capital and maintenance dredging. Two disposal sites with prevailing depth of about -15.0 m CD in open sea near Mumbai harbour were considered. Simulation results using regional model indicated that equilibrium dispersion could be obtained after 3 days of real time. Area of the sustained spread of the material with maximum concentration of about 0.06 kg/m<sup>3</sup> was found to be about 15 km<sup>2</sup>. Simulation results further indicated that the disposed material would not enter into the navigational channel or into the Mumbai port channel or any other area near the shore.

**Keywords:** *Dredging; disposal; dispersion; hydrodynamics; creek; river.*

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**THEME- II**  
**COMPUTATIONAL FLUID DYNAMICS/ NUMERICAL**  
**MODELLING**



Paper ID – 021

## Aerodynamic Study of an Ahmed Body with the help of CFD Simulation

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### Abstract

Automotive aerodynamics comprises of the study of aerodynamics of road vehicles. Its main goals are reducing drag, minimizing noise emission, improving fuel economy, preventing undesired lift forces and minimizing other causes of aerodynamic instability at high speeds. The Ahmed body has the form of a highly simplified car, consisting of a blunt nose with rounded edges fixed onto a box-like middle section and a rear end that has an upper slanted surface, the angle of which can be varied. It retains vital features of real vehicles in order to study the flow fields around it and the related turbulence models which characterizes the actual flow at elevated Reynolds number. In the present study, the aerodynamic behavior of this body is investigated numerically by the aid of commercial CFD tool: Ansys Fluent. The results of the simulation are validated with available experimental data and results of the simulations from other literatures. The numerical data were obtained for a fixed free stream velocity of 25 m/s at the inlet. The simulations were performed at a fixed slant angle of 25 degree and zero yaw angle. The present study focuses on how local refinement of mesh inside the concerned body and the outside, helps affect the results and for which grid dependency test is the primary objective of this paper. The present study also helps demonstrate how the drag of the body behaves, which is mainly the effect of pressure drag force generated at the rear portion of the body. The study also focuses on important properties like the velocity magnitude at different locations for different meshing cases, and to capture the flow pattern in the front or near the wake region. The study can be further helpful to future researchers in determining resistance, fuel efficiency etc. helping designers to optimize in specialized areas for better efficiency.

**Keywords:** Ahmed Body, vehicle aerodynamic, Drag force measurement, Numerical simulation/investigation

Paper ID – 034

## CFD Analysis of Flow through Concentric, Eccentric and Segmental Orifice Meters

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### Abstract

Accurate measurement of fluid flow is an essential task for many industries. An orifice meter is widely used in process industry, chemical industry, oil, and gas industry for flow rate measurement of steam, oil, gas, etc. The common types of orifices used in industries are concentric, eccentric, and segmental orifices. The concentric orifice is the most used design because of its proven reliability in a variety of industrial applications. Eccentric orifice plates are generally used when the process material contains foreign matter that may block the orifice in the case of concentric configuration. Segmental orifice plates are used to measure the flow of light slurries and fluids with a high concentration of solids. The present study aims to determine the coefficients of discharge, pressure contours, and velocity streamline patterns for selected concentric, eccentric, and segmental orifices by using ANSYS CFD software. From the results, it is observed that the sharp edge with 45° back cut concentric orifice meter has the maximum discharge coefficient value, velocity streamlines, and minimum pressure drop value when compare with square-edged and square-edged with 45° back-cut concentric orifice meters. The



discharge coefficient and velocity streamlines are gradually increased and pressure drop decreases with the increasing of the eccentricity of the orifice. In the case of segmental orifice, with increasing the opening of orifice the discharge coefficient value is increases, and the pressure drop value is decreased. The results can be used to select the most suitable geometry of the orifice plate in practical applications.

**Keywords:** *Computational Fluid Dynamics, Orifice Meter, Concentric, Eccentric, Segmental Orifice and ANSYS-Fluent*

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Paper ID – 056

## **The Significance of Numerical Simulations for Hydrogeological and Groundwater Flow Modelling studies in the mining areas**

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### **Abstract**

The complex hydrogeological situations in open pit and underground mines is a constant threat to the mining operations and environment. Simulations of open pit mine dewatering, water rebound problems, pollutant transport and their environmental impacts are needed to be assessed. Accumulation of rainfall and runoff in case of open mines can make working conditions more difficult. Also, water flow, uplift pressure and piping can lead to the slope failure and excessive flow of water into the pits can lead to flooding. To estimate the impact of environmental risks during and after the mine closure, a numerical model is needed which rely on the appropriate study of the hydrogeological system of the mines. Despite of having several limitations, the groundwater flow models shows the most appropriate results where classical approach fails to do so. However, periodical verification based on latest data and aquifer parameters is always required. The main aim of a numerical model is to provide a clear picture of the water flow dynamics in the mine pit. The objectives of a numerical hydrogeological model is to investigate the hydrodynamic parameters i.e. flow regimes, water velocity in the aquifer strata and discharge volumes. This paper reviewed some specific features and problems of numerical modelling application in mine hydrogeology.

**Keywords:** *Groundwater modelling, Mining, MODFLOW, Dewatering*

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Paper ID – 096

## **HYDRAULIC STRUCTURE DESIGN WITH 3D CFD MODEL**

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### **Abstract**

Design of hydraulic structures requires various inputs for dealing with Structural and Hydraulic aspects. Hydraulic structures like pump intake, Fish ladder and barrage need input in the form of water level, velocity as well as real



picture of flow taking place at and around the structure. Design of intake structure must ensure that prevailing norms are adhered, flow is as axial as possible, and vortices are not formed during operation. This aspect needs to produce 3D picture of flow in the pump-sump area. Such a view can be obtained through 3D simulations using either hydraulic scale model or mathematical models. Each of this technique has its own advantage and limitations. At times it is necessary to know the behavior of the structure from sediment movement perspective. Authors have been using CFD modelling technique of structures like intake, barrage, and fish ladder over one decade and have carried out designs of above structure on river and estuaries. CFD modelling is becoming popular tool due to inherent advantages like less time required, flexibility to simulate different scenario and relatively less cost than hydraulic scale model. It is proposed to present design aspects of above structures and case study of an intake channel and pump station on river Narmada in the state of Madhya Pradesh using FLOW3D software.

**Keywords:** *CFD Modelling, Flow3D, Hydraulic Structures*

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Paper ID – 130

## **Performance of Mac-Cormack finite difference scheme with TVD and Artificial Viscosity**

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### **Abstract**

Numerical experiments for instantaneous dam break flow are presented in this paper. The governing equations for one-dimensional shallow water hydrodynamic are solved using Mac-Cormack finite difference scheme. Numerical scheme to simulate dam break flow requires shock capturing capabilities. Here, we applied two different methodologies to dampen the numerical oscillation. Firstly, artificial viscosity is added to the Mac-Cormack Scheme. Numerical performance of the scheme is presented at various pre-break upstream to downstream flow depth ratio. Secondly, a Total Variation Diminishing (TVD) scheme is added to the Mac-Cormack Scheme to verify the same. We have observed better shock capturing capacity while using TVD Mac-Cormack scheme. A flood hydrograph is also simulated using original Mac-Cormack scheme, artificial viscosity and Total Variation Diminishing (TVD) scheme. Similar results are observed from all three approaches in case of flood hydrograph simulation however, it is observed from dam break analysis that TVD scheme has better shock capturing capability.

**Keywords:** *Mac-Cormack scheme; artificial viscosity; Total Variation Diminishing*

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Paper ID – 192

## Comparative Study of Mixture Model and Eulerian Model used in Hydro cyclone with the help of CFD Simulation

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### Abstract

Due to the accuracy of numerical calculation of fluid flow inside a hydro cyclone can be obtained using Computational Fluid Dynamics (CFD), highly modified super computers are used to simulate the fluid flow and track particle motion inside a hydro cyclone. This paper deals with the numerical study using three multiphase models viz. Volume of fluid, Mixture and Eulerian model. The dimensions of the hydro cyclone taken into consideration for numerical analysis are same as considered by Rajamani. Validation of axial and tangential velocities at different strategically decided axial stations, RMS axial and tangential velocity profiles of the hydro cyclone is done using Reynolds Stress Model (RSM). The hydro cyclone model has been designed in Creo 3.0 using the same dimensions which later was imported to CFD for meshing. Fine hexagonal mesh numbering up to 5 lacs were constructed to obtain optimum results. Fluid flow was allowed to be developed in ANSYS FLUENT 16.2. Entire simulation took 96 hours to generate results and track particle movements inside the hydro cyclone. The particle tracking has been done using three multiphase model. The first being the volume of fluid was used for validation purposes and the comparison of the Mixture and Eulerian model are the basic focus of this research work. Conclusive results indicate that usage of different multiphase model does not result in variation in particle motion. The slight variation in grade efficiency values is hardly noticeable. The Mixture model and Eulerian model predict lower separation efficiency as compared with Volume of fluid multiphase model.

**Keywords:** RSM, LES, DNS, Simulation/Numerical investigation, Air-core, Vortex, Grade efficiency

Paper ID – 196

## Application of FLUENT Software in Determination of Permeability of Soil

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### Abstract

Proper assessment of ground water recharge, design of earthen dams, and slope stability analysis of embankments require the knowledge of permeability of water through porous media. This property of soil plays a vital role in the planning and design of such structures. The flow of water in porous media can take place in any direction as per the availability of slope, geological conditions of the area and soil characteristics. In this study, flow of water in two well defined directions viz. vertical and horizontal have been considered for the determination of permeability. As the permeability is dependent on number of factors such as characteristics of soil, orientation of soil mass and properties of fluid, its analytical determination in such situations becomes complex problem. Thus, software FLUENT 14.0 of ANSYS was utilized for the determination of permeability. Different samples of soil were selected which are found at different depths in the earth crust such as coarse sand, fine sand, silt and clay.



Fly ash was also included in the study as this material is being increasingly used now- a - day in earth fills. Permeability of the selected materials was determined in vertical as well as horizontal direction using the said software. The results obtained were validated by experimental observations. The simulated values were found in close proximity to the observed values. The permeability anisotropy, also determined. This ratio was found within the range reported by other investigators.

**Keywords:** *Permeability, Anisotropy, FLUENT 14.0.*

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Paper ID – 217

## **Development of two dimensional 9-noded Lagrangian quadratic isoparametric element mesh generation tool for Finite Element Models**

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### **Abstract**

With the advent of high performance computing facilities, PDEs representing most complex physical processes are solved using numerical methods, such as Finite Difference Method (FDM), Finite Volume Method (FVM) and Finite Element Method (FEM). FEM is widely adopted and requires inversion of property matrix to obtain the behavior matrix that is a time consuming step. However, the Explicit FEM (EFEM) suggested by Gray and Lynch (1979) uses the 9-noded Lagrangian quadratic isoparametric elements with Simpson's 9-point integration rule resulting in a diagonal property matrix. The solution of the diagonal property matrix is straightforward and substantially reduces the computational effort. The 9-noded element can capture the field variables more accurately within the element, which further enhances the accuracy of numerical results, which may not be possible through other type of elements. Because of these properties of 9-noded Lagrangian quadratic isoparametric element, it is used to discretize large domains such as Bay of Bengal, Arabian Sea, Indian Ocean, etc. for the solution of coastal dynamics and environment such as tidal flow computation and tsunami computations. The importance of 9-noded Lagrangian quadratic isoparametric element mesh and unavailability of open source software/modules for mesh generation motivated to develop an in house 9-noded mesh generation tool. Initially, a tool (programmed using MATLAB) has been developed to generate quadrilateral elements mesh for rectangular and circular domains. The tool could generate uniform mesh using quadrilateral elements for the mentioned standard domain shapes. The tool also has the option to extract the nodal coordinates and nodal connectivity of the elements required for Finite Element Analysis models. The program was further extended to generate 9-noded mesh for two-dimensional rectangular region, and obtain nodal coordinate and element connectivity matrices, which are very useful in solving standard two-dimensional problems using Finite Element Method. The tool can be extended for various domain shapes inclusive of obstructions for versatile applications.

**Keywords:** *9-Noded Lagrangian Quadratic Isoparametric Element; Simpson's 9-point Integration; Mesh Generation; Finite Element Method*

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Paper ID – 254

## Application of computational fluid dynamics in investigating orifice spillway flow

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### Abstract

Orifice spillways are provided in Run-of-the river diversion dams in Himalayan region where the management of sediment along with flood is the main issue. Analysis of hydraulic behavior of flow over orifice spillway is very significant considering the safety and efficiency of the dam. Orifice spillways are exposed to two-phase flow, high velocity, cavitation, scouring and downstream erosion. Conventionally, physical modelling is a proven technique for simulating such complex hydraulics problems, but it is time-consuming and uneconomical. However, computational fluid dynamics modelling is advantageous because of recent developments in high-performance computing. The performance and reliability of numerical modeling depend upon grid convergence studies and the selection of the turbulence model. This paper aims at the selection of the grid and turbulence model for analyzing the flow over orifice spillway with ski-jump dissipator. The spillway considered in this study is one of the run-of-river hydropower schemes in the Himalayan region. It is designed to pass a flood discharge (PMF) along with GLOF. Physical model studies were carried out to analyze the flow through the breastwall spillway incorporating one full span and two half spans in a 1:40 scale sectional model at the CWPRS laboratory. CFD software, FLOW-3D based on VOF was used for numerical model studies. For verification studies, the technique of Grid Convergence Index as suggested by the ASME was utilized to determine appropriate grid dimensions and minimize discretization errors. The RNG turbulence model was used for numerical simulation. The data in terms of discharging capacity, pressure distribution along with the spillway profile and water surface profile were computed in the numerical model. Validation of numerical model results with physical model results was done. It was found from the present study that the RNG turbulence model is slightly better than K- $\epsilon$  and K- $w$  turbulence model and FLOW-3D could able to simulate the various hydraulic parameters of spillway flows accurately as there was close agreement between the simulated values and experimental results.

**Keywords:** Orifice spillway, CFD, Grid Convergence, FLOW- 3D, Turbulence model, Discharging Capacity, Pressure Distribution, Water Surface Profile.

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Paper ID – 257

## Study on influence of vegetation in open channel using CFD model

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### Abstract

Vegetation in open channel flow will cause some roughness and generate drag on flowing water. The drag force generated by this will reduce the water discharge and also influences the sediment load transportation. The prediction is very difficult because the flow in open channels is usually turbulent; the geometry is irregular and can vary with time. In the present study, influence of the vegetation on the flow characteristics was determined numerically using computational fluid dynamics (CFD). For the numerical study of the vegetated channel, two CFD approaches viz., the stem scale approach and the porous zone approach were used. The obtained results were then compared with the available experimental results. The various hydraulic parameters which describe the flow characteristics of the vegetated channel were also determined using two CFD approaches and compared. The CFD model with the porous zone approach, which better predicted the hydraulic parameters, was found to be superior to the stem scale approach. The average value of the Manning's roughness coefficient for each vegetation cover was determined and it was found that the roughness coefficient increases with increase in the vegetation cover.



**Keywords:** *CFD, Stem scale approach, Porous zone approach*

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Paper ID – 277

### **Computation of gradually varied flow depths in a channel system using numerical methods**

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#### **Abstract**

A channel helps in transportation of water from a main source to the field where the crops are located thus making possible to feed our nation. It is very important to predict the water level at different section of channel because this will help to determine if the water level, at a specific point, and will provide the necessary discharge of water. It has been established that flow through channels are basically gradually varied flow. Due to differences in the hydraulic and geometric properties of channels, we have to look for the numerical methods that provide accurate results. In this paper, computation of gradually varied flow has been done by using different software like MATLAB and HEC-RAS. In MATLAB, algorithm has been encoded to determine water level at different sections by using Direct step method and Fourth-order Runge-Kutta method. The result obtained from software has been compared well and percentage error has been calculated to find out the better method. Merit and demerits of the methods are discussed.

**Keywords:** *channel; water level; gradually varied flow; numerical methods; MATLAB; algorithm*

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Paper ID – 283

### **Numerical solution of 1D Saint-Venant equation by MacCormack Method and Comparison of result with Preissmann Implicit Method**

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#### **Abstract**

In water resources management river flow prediction is highly essential. For the river flow prediction unsteady flow analysis plays an important and vital role than the steady state analysis because in practical scenarios there is no existence of steady flow. For the study of unsteady flow in open channels Saint-Venant introduced two equations (Continuity and Momentum equation) in the form of Non-linear partial differential equation. As these equations are highly nonlinear so they don't have analytical solutions. To solve these equations numeric methods can be utilized effectively. This Paper presents the numerical solution to the Saint-Venant equation that governs the propagation of flood wave by using a finite difference method. To solve these nonlinear partial differential equations a mathematical model with the initial and boundary conditions is established. The Model is then discretised by using a MacCormack finite difference method and implemented on MATLAB. The output



parameters like depth of water ( $y$ ), the fluid velocity ( $u$ ) and the volumetric flow rate ( $Q$ ) are simulated numerically and values are obtained for the different time at different cross sections to plot outflow hydrograph for the downstream sections. To solve these highly nonlinear equations through the MATLAB programming proper discretization with proper selection of grid size and time step is highly essential. Conversion of these equations into partial differential equation forms and the simple discretization of these equations by MacCormack explicit scheme using CFD techniques and the comparison of the result with other implicit and explicit models are presented in this paper.

**Keywords:** Saint-Venant equations, MATLAB, MacCormack scheme, CFD, Explicit, Implicit

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Paper ID - 342

## Numerical Simulation of Undular Hydraulic Jump on Smooth Bed

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### Abstract

In Open Channel Flow, the transition from supercritical to subcritical flow is called hydraulic jump. For low upstream Froude numbers free surface on the downstream side of jump develops undulations, these hydraulic jump is known as undular hydraulic jump. In this study, flow model is presented to predict the undular hydraulic jump in rectangular channel with smooth bed. The model is based on the general two-dimensional Reynolds-Averaged Navier–Stokes flow equations. The resulting set of partial differential equations is solved using the Ansys Fluent program.

**Keywords:** Undular hydraulic jump; Navier-Stokes Equation; Numerical simulation; Ansys Fluent;

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Paper ID - 471

## Numerical modelling in shoreline evolution prediction: case study of inlet channel at Kasargod, Kerala

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### Abstract

Longshore sediment transport comprising complex phenomena is an important factor in shoreline change in response to marine structures. Longshore sediment is mainly driven by waves rather than tides and ocean currents. Prediction of beach morphological changes is of paramount importance for various coastal engineering projects and proper management of coastal zone. In the present study, mathematical modelling is applied for prediction of shoreline evolution for the proposed 700 m curve shaped extension of North breakwater in the inlet channel at Kasargod, Kerala located at confluence of the northern creek and the downstream of the river Chandragiri. The study includes evaluating historic shoreline performance and changes in its behavior. The paper demonstrates that LITPACK package developed by DHI could be successfully applied to reproduce the natural conditions and altered conditions due to manmade implementation in the shoreline environment. The LITDRIFT module showed annual longshore sediment transport. The LITLINE module predicted the shoreline



morphological evolution. Shoreline evolution of the proposed scenario after 2 years, 4 years, 6 years and 10 years are gradually enhancing. As per model simulation, after 10 years cross-shore movement in northern side is about 355 m and in southern side about 72 m.

**Keywords:** Fishing harbour; wave; creek inlet; shoreline; longshore transport

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Paper ID - 488

## **Real Time Decision Support System (RTDSS) using MIKE software package for operational management of reservoirs - A case study of Bhakra and Pong reservoirs**

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### **Abstract**

Bhakra Beas Management Board (BBMB) operates two major reservoirs namely Bhakra and Pong on Satluj and Beas rivers with designed capacity of 9.87 BCM and 8.58 BCM respectively and combined average inflow of 27 BCM. The BBMB reservoirs in addition to hydro-power generation, distributes irrigation water to Punjab, Haryana and Rajasthan, and water supplies to Chandigarh and Delhi. Water management is now facing new challenges due to climate variability and extremes, making the traditional method of reservoir operation obsolete. BBMB with the consultancy services of DHI developed a Real-Time Decision Support System (RTDSS) for Operational Management of BBMB Reservoirs. The RTDSS integrates state of the art data acquisition system (real time and forecasted weather information), inflow forecast modelling, optimization, and analysis tools in a single IT system, designed for ease of use by operators. MIKE Operation, platform for decision support, comprises a large suite of generic and flexible software components. MIKE 11 NAM (for Rainfall-Runoff/Snowmelt-Runoff Modelling) and MIKE 11 HD (for water levels & discharges along the rivers sections) are operating automatically within the RTDSS and are combined with the database to provide comprehensive information on the present and future state of the basin. BBMB with the help of RTDSS has tackled the problems posed due to climate change including drought, floods, historical minimum, and maximum snow deposition. The real time information of weather and inflow forecasts, reservoir level scenarios and automated information generated through RTDSS helped in successful operational management of reservoirs. This paper discusses about the management of reservoirs in BBMB through RTDSS.

**Keywords:** BBMB; Reservoir Operation; Climate Variability; RTDSS; Water Management; inflow forecasts; MIKE Software

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## Design of Multistage Centrifugal Pump and Performance Analysis using CFD

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### Abstract

A multistage centrifugal pump is basically a type of regular centrifugal pump which has more than one impeller arranged in series on a single shaft of rotor. It consists of impeller, diffuser and return channel passage. To study numerical simulation of multistage pump first a single stage pump is model in Nx-CAD and is analyzed of different number of impeller blades i.e. 5, 6 and 7 at different speed 1450 rpm, 1600rpm, 1750rpm and 1900 rpm. The governing equation is solved using k-ε turbulence model. It is observed that as number of blade and speed increases, the performance of the pump improves. Best performance is obtained for 7 blade impeller at 1900 rpm.

**Keywords:** CFD; Numerical analysis; multistage pump; centrifugal pump

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## Seepage and Stability Analysis of Earthen dam in Slow and Rapid Drawdown Conditions

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### Abstract

Slope stability during reservoir drawdown is the most important consideration for embankment dam design. Reservoir water pressure has a stabilizing effect on the upstream dam faces under operating condition. The stabilizing effect of the water is lost during rapid drawdown condition but the pore water pressures that remains within the embankment, may remain high. Due to which the dam stability along the upstream face of the dam, may decrease until the high pore water pressure within the dam dissipate. Dissipation of pore water pressure depends on the permeability and storage characteristics of the embankment materials. Highly permeable materials drain quickly but low permeable materials takes time to drain during rapid drawdown condition. The rapid drawdown occurs when a slope that is used to retain water experiences a sudden lowering of the water level and the internal pore pressures in the slope cannot reduce fast enough (Khassaf et al., 2013). Zomorodian and Abodollahzadeh (2010) investigated the effect of horizontal drains on upstream slope of earth fill dams during rapid drawdown using finite elements and limit equilibrium methods. Noori and Ismaeel (2011) stated that seepage can cause weakening in the earth dam structure, followed by a sudden failure due to piping or sloughing. Chugh (2013) examined the stability of a circular earth dam for radial cracking potential and static slope stability using continuum mechanics-based three-dimensional numerical models.

#### About dam

Khamar Pakut dam is an earthen dam, which is located in Gharghoda Tahsil in Raigarh District. It is built on Khadun river. The length of the main dam is around 14.70 km and maximum height is 23.86 m with 4.57m top width. Mean monsoon yield is around 30.40 M.cum and Gross Storage capacity 21.88 M.cum. It serves 18 villages with total command area of 15300 Acres and culturable area of 13350 Acres.

**Keywords:** Slope stability; Seepage; Instantaneous drawdown; slow drawdown

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## **State of Art: Hydraulic design of storm water drainage system of Nuclear Power Plant using 2-D numerical simulation**

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### **Abstract**

The effects of flooding on a nuclear power plant site may have a major bearing on the safety of the plant and may lead to a postulated initiating event (PIE) that is to be included in the plant safety analysis. Deficiencies in the site drainage systems may cause flooding of the site. The presence of floodwater within the plant may be a cause of failure for safety related systems, such as the emergency power supply systems or the electric switchyard, with the associated possibility of losing the external connection to the electrical power grid, which in turn may affect the decay heat removal system and other vital systems. Globally in the past consequent large-scale damage are reported due to flooding, therefore flooding hazard evaluation needs to be considered in the design of drainage system for site protection. In the present paper, a study has been carried out for the hydraulic design of storm water drainage system under critical events. The drainage system is designed for discharging floodwater corresponding to 100-year Mean Recurrence Interval (MRI) rainfall and adequacy check is carried out for 10000-year MRI rainfall considering overflow within the permissible limits. In order to carry out the adequacy check of the drainage network, detailed 2-D numerical simulation of plant site is carried out. Drainage network is developed such that the utilization of the drains under the normal as well as under extreme events is maximum and the safety related systems and escape routes are accessible under extreme flood resulting from 1 in 10000-year precipitation.

*Keywords: drainage network, flooding, 2-D simulation*

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**THEME- III**

**FLOOD FORECASTING AND MANAGEMENT**



Paper ID – 014

## **Flood Frequency Analysis Using Gumbel's Distribution Method: A Case Study of Sita River, Karnataka, India.**

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### **Abstract**

Estimation of Peak Flood Discharge for a desired return period is a pre-requisite for planning, design and management of hydraulic structures like barrages, dams, spillways, bridges, etc. The main objective of the study was to carry out the Flood Frequency Analysis for the Sita River, one of the West flowing rivers in Karnataka, using the discharge data of Avershe Weir for a period of 13 years, from 2003 to 2015. The annual maximum discharge of the river from Avershe Weir for a period of 13 years, from 2003 to 2015. The mean instantaneous flow in the river is 548.23 m<sup>3</sup>/s with a return period of about 2.5 years. The R<sup>2</sup> value of 0.9783 obtained from the regression analysis, indicates that the Gumbel's distribution is suitable for predicting the expected flow in the river. Hence, using the Gumbel's distribution analysis, the flood with different recurrence intervals were also computed, which will be useful for future storm management in the area.

**Keywords:** Flood Frequency Analysis; Gumbel distribution method; Sita River; Regression Analysis; Peak flood discharge; Return periods.

Paper ID – 066

## **Investigating the role of streamflow forecasts to mitigate floods in the delta region of Mahanadi River basin**

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### **Abstract**

Floods affect millions of people all around the globe annually. About 7.5 million hectares of area is affected by floods in India every year causing severe destruction to life and property. In this study, major source of flooding in the Mahanadi River basin in the recent past was analyzed. The releases from the Hirakud reservoir were routed to the Mundali gauging site using a calibrated and validated MIKE 11 HD model. The contribution of the middle reaches at Mundali were obtained by subtracting the routed releases from the observed discharges at Mundali. A flow duration curve analysis at Mundali for the Q<sub>5</sub> threshold level was performed to identify the years receiving significant flow from the Hirakud reservoir. Critical analysis of observed discharges in these years revealed that high floods in the delta reaches of the basin occurred due to significant contribution from the reservoir releases during 2001 and 2011. High correlation (0.748) between inflow to Hirakud and its releases indicated that most of the incoming flows were released on the same day without storage. Analysis of the inflow-outflow and reservoir level maintained at the Hirakud reservoir during the monsoon season of the years receiving high floods indicated that inflow forecasts to the reservoir with sufficient lead time could have helped in systematic release of the storage prior to the flood event. This would have aided to keep storage capacity of the reservoir available for storing further high inflows. Hence, forecasted reservoir inflows can be attributed to play a vital role in preventing havoc created by floods in the downstream reaches of large river basins with tropical pluvial regime. This study can



provide an insight to the planners and decision makers in design and management of structural flood control measures.

**Keywords:** Flood forecasting; MIKE 11 HD; flow duration curve; floods; Mahanadi River basin

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Paper ID – 088

### **Flood risk assessment and mapping using AHP: A case study in Thuthapuzha river basin, Kerala**

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#### **Abstract**

Flood is one of the most destructive natural hazards which distresses substantial damages to mankind, infrastructures, agronomic and economic systems. Flood risks have been assessed with the combination of hazard and vulnerability index which extensively used as a vital tool for the formulation of flood management strategies. The main objective of this study is to comprehend the probability and magnitude of the occurrence of flood hazards and the extent of vulnerability to flood in order to map the risk zones in Thuthapuzha river basin (Kerala) using Multi-Criteria Analysis (Analytic Hierarchy Process-AHP). The concerned area of study is one the main tributary of Bharathapuzha where the river has changed its course by collapsing the river banks during the 2018 however; it has never been investigated in terms of flood risk assessment. In this study, the flood hazard map is prepared using meteorological and topographical parameters whereas vulnerability map is prepared using demographic and infrastructural parameters.

**Keywords:** Flood Risk; AHP; Vulnerability; Hazard; River Basin; Kerala

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Paper ID – 097

### **Application of L-Moment based Regional Flood Frequency Analysis for Krishna River Basin**

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#### **Abstract**

Flood is one of the worst and costliest natural disaster which results in great loss of mankind and nature. Design flood estimates are desired at locations of interest along the river network. Design flood estimation becomes a difficult task when historical streamflow records are not available at the locations of interest, famously known as ungauged locations. L-moment based Regional Flood Frequency Analysis (RFFA) helps in estimating design flood estimates at ungauged locations. In this paper, RFFA was applied to catchments in Krishna River basin. In RFFA, hydrologically similar regions were identified through a Global K-means clustering algorithm. Discordant sites were recognized with the help of discordancy measure. Subsequently, homogeneity test was performed to make regions homogeneous in terms of their flood response. Finally, leave-one-out-cross-validation (LOOCV) was used to investigate the performance of formed regions in predicting design flood estimates. Results indicated that RFFA can be effective for reliable prediction of design flood estimates in Krishna River Basin.

**Keywords:** L-moment; Global K-means; discordancy measure

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Paper ID – 202

## Assessment of floodplain mapping of Ulhas River basin using HEC-RAS 1D/2D hydraulic simulation

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### Abstract

The study presents flood modeling and floodplain mapping of Ulhas River basin, Maharashtra using HEC-HMS, HEC-RAS model, along with ArcGIS's GeoRAS for floodplain visualization. The work's focus is to find out the suitability of the HEC-RAS model for simulating water surface profiles of the Ulhas River basin for the different return periods. The Ulhas River is a west-flowing river that originated in the Western Ghat and home to about 10 million people and the six major municipal corporations of the Mumbai Metropolitan Region (MMR). The average annual rainfall of about 2500 mm and the rapidly changing land-use make the Ulhas River basin more vulnerable to floods. The urban and pavement area is increased by 145 Sq. Km and the broadleaf forest is shrinking by 142 Sq. Km in the basin since the year 2001. Also, the mixed forest, wasteland, evergreen forest, and plantations decreased. For flood plain mapping, the SRTM's DEM of 1 arc-minute is used for the river cross-section. The IDF curve is calculated using IMD, Kothari Grade, and Modified Kothari Grade formulas for different return periods and incorporated in the HEC-RAS model for floodplain mapping. The analysis of floodplain mapping shows around 3.5 times the area of the river's natural flow inundated and vulnerable to the flood for 100-year return period, mostly the Urban built-up and agricultural land of Badlapur Municipal corporation. The simulation of the 2019's flood shows a good correlation compared with the ground survey and Landsat 8 images.

**Keywords:** Flood; HEC-RAS; Floodplain mapping; Ulhas River.

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Paper ID – 249

## Flood Inundation Mapping of Chalakkudy River using HEC RAS

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### Abstract

Flood mapping with respect to discharge or water level through the river is a pre requirement for any flood disaster management, evacuation or rehabilitation plan. Flood, that occurred in Kerala during 2018, known as flood of the century causes loss of lives, properties and massive destruction to infrastructure. Chalakkudy town, located near the bank of Chalakkudy river, was one of the most affected area during the flood. The flood mapping for a selected stretch on either banks of Chalakkudy river including the town is performed to understand the flood severity and the inundation depth. In order to account the meandering nature of the river, a two dimensional model is taken for flood inundation study using HEC RAS The flood inundation map is prepared and validated by site investigation.

**Keywords:** flood mapping, Kerala flood, inundation map

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Paper ID – 291

## Non-stationary Flood Frequency Analysis of Westflowing Rivers of Kerala using Bayesian Inference Approach

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### Abstract

Climate change has become a global concern over the past few decades and it has got a critical impact on hydrological cycle. Climatic changes display a general tendency to amplify hydrologic extremes and the hydraulic infrastructure should be capable to cope with such changes. Current practice of infrastructure design uses the hydrologic tools like flood frequency curves developed based on stationary assumption of hydrological data. Such a practice may lead to the underestimation of flood quantiles under non-stationarity of hydrologic data resulting from climatic changes. Development of non-stationary frequency analysis models is gaining popularity to avoid the failure of critical infrastructure under a changing environment. This paper presents the application of Bayesian Inference Approach (BIA) for the flood frequency analysis of 14 hydrologic stations of west flowing rivers of Kerala, India. The annual maximum stream flow was idealized to follow Log- Pearson Type III distribution with time varying parameters estimated in a Bayesian interface. From the analysis it was found that, the data of stations Ayilam and Perumanur were experiencing significant non-stationarity (> 25%) in the most likely estimates of discharges irrespective of the return period, over the stationary counterparts. The study showed that there exists a wide variability in the percentage change in non-stationary over the stationary estimates of flood quantiles in the state, for different return periods. The longer return period estimates show high degree of non-stationarity over the shorter return period estimates throughout the state, while the effect of non-stationarity is found to be significant even in the lower return periods at few locations. In general, it can be concluded that non-stationarity must be accounted for the design with longer return period applications (> 200 year) in all locations, while it must be accounted for smaller return period design (< 50 year) applications in few selected locations.

**Keywords:** Climate change; hydrologic extremes; infrastructure; non-stationarity; flood frequency; return period

Paper ID – 458

## Web Interface for Random Sea Wave Generation and Data Acquisition System for Hydraulic Physical Model Studies

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### Abstract

Random sea wave generation is an extremely important method used for modelling and development of shallow basin physical wave models in coastal engineering for planning of ports and harbours. For generating random sea waves and data acquisition in models, an electro-hydraulic based wave generation system including a Programmable Logic Controller (PLC), servo controller, multi-channel capacitance wave height recorder,



Supervisory Control and Data Acquisition (SCADA), differential pressure filtering system and a wave board assembly is extensively used. Random Sea Wave Generating (RSWG) Systems are used to simulate prototype sea conditions in laboratory like wave flumes for studying of maritime structures namely breakwaters, sea walls and shallow basin wave models for finalisation of port layouts and berthing alignments. For ease of accessing the model experimental results from a remote location with internet facility, a web interface has been developed using tools such as Python and JavaScript, making it easier to access the data and results for the modelling studies. This eliminates the need to physically access the data from the model each time when any studies being carried out. By doing so experts in the field can guide the laboratory experiments remotely thus saving their time and as well timely completion of studies can be achieved. The main tools used for this are Python, JavaScript, HTML and plotting libraries such as Plotly (for JavaScript) and matplotlib (for Python). This paper elaborates on the web interface created to view the data collected from the physical models with additional features added such as zooming in and saving as an image to be printed, etc.

**Keywords:** *Random sea wave generation, hydraulic physical model, data acquisition system, web interface.*

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Paper ID – 462

## 2-D Flash Flood Modelling of Vamasadhara River basin

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### Abstract

The Vamsadhara river basin is situated between the Mahanadi and Godavari river basins of south India. The total catchment area of Vamsadhara river basin, upstream to the point where it joins the Bay of Bengal, the river originates from the border at Thuamul Rampur in Kalahandi District and Kalyansinghpur in Rayagada district in Odisha and travels for a distance of about 254 km. The total catchment area of the river basin is 10,830 sq.km, Vamsadhara river basin occupies 8,015 sq.km in Odisha and the remaining 2,815 sq.km in Andhra Pradesh and lies within the geographical co-ordinates of 18° 15' to 19° 55' north latitudes and 83° 20' to 84° 20' east longitudes. Vamsadhara river is a non-perennial river so the only source of flow was rainfall. The basin is influenced by the south-west monsoon during the months of June to October, and by occasional cyclones due to the formation of depression in the Bay of Bengal. Highest rainfall was recorded in the basin during 2006 monsoon season over the period of 50 years from 1971-2020 and the river was over flooded which caused lots of losses either economic or loss of life. In this paper, the methodological approach was adopted, focused on the hydrologic modelling through the Hydrologic Engineering Centre Hydrologic Modelling System (HEC-HMS) and the hydrodynamic modelling with Hydrologic Engineering Centre River Analysis System (HEC-RAS). The aim of this study was flood inundation behavior of vamsadhara river basin during extreme flood event in 2006 year. HEC HMS model output results are used in the hydrodynamic model (HEC-RAS) to simulate the flash flood. Hourly rainfall data downloaded from (CHRS) and simulated flash flood using 2- Dimensional HEC RAS. 2-D HEC RAS model was simulated by using output results of HEC HMS hourly runoff depth/excess rainfall and simulated results of Gunbupur and Kashinagar GD station ( $R^2$  are 0.766 and 0.777) are well match with observed data. Flash flood model is very useful for flood warning system by generating pre-flood inundation maps and decision makers.

**Keywords:** *Flash Flood, Rainfall, Model, Runoff, Simulation*

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## Flood Resistant and Amphibious Houses: An Overview

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### Abstract

Among all the natural disasters that the country faces, river floods are the most frequent and often the most devastating. Floods are sources of large scale destruction and are among the most common natural hazards causing extensive damage to infrastructure, economy and devastation to human settlements. Recurring flood losses have handicapped the economic development of both developed and developing countries. It takes several months or even years before the community comes to the pre-flood level. So floods are a natural and inevitable phenomenon of life in almost all the states of India. India is highly vulnerable to floods having more than 40 MHA flood prone area. The frequency and intensity of floods have grown in the country over the years mainly due to the increase in the encroachment of floodplains of rivers and extreme events of precipitation. A solution to this problem has to be put forward to mitigate the flood havocs by constructing Amphibious and Flood Resistant Houses. In this paper, an attempt is made to put forward an overview of Flood Resistant and Amphibious Houses and suggest the measures to be adopted in the design of such houses with an eye on new techniques developed in different parts of the world.

**Keywords:** Amphibious houses; flood resistant houses; natural hazard; precipitation

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**THEME-IV**  
**GROUNDWATER MODELLING & MANAGEMENT**



Paper ID – 003

## Determining hydro chemical backgrounds in a part of Krishna delta to implicating mass transport modeling

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### Abstract

Groundwater is continuously getting polluted due to the increasing agricultural activities, rapid growth of urbanization, industrialization, and saline water intrusion not only in India but also worldwide. Detecting and evaluating the effects on groundwater pollution by human activities and natural impact are keys to finding the hydro chemical backgrounds, which essentially support the mass transport modeling. Thus this article emphasizes the cumulative probability distribution of analytical hydro chemical data collected from a part of Krishna delta, Andhra Pradesh, to estimate the backgrounds on groundwater chemistry and quantified its abnormality. Results show one threshold value, which indicating mainly two processes, are involved in the groundwater pollution in this coastal area. The background ranges of EC, Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, CO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup> and F<sup>-</sup> are determined from 652 to 2000 μS/cm, 31 to 95, 2 to 15, 26 to 119, 10 to 56, 52 to 260, 108 to 296, 12 to 40, 3 to 60, 0.9 to 40.0, and 0.12 to 0.20 mg/l, respectively. Whereas first threshold values of TDS, Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup> and K<sup>+</sup> ions are estimated about 906, 182, 60, 160, and 5 mg/l, respectively. With the help of the threshold values, the pollutant spreads have been demarcated along with the backgrounds of the hydro chemical constituents. This information helps to demarcate the occurrence of seawater intrusion, and assign backgrounds for the mass transport modeling, which will support for sustainable management of groundwater resources in this coastal area.

**Keywords:** *Groundwater pollution, Major ions, Probability distribution, Hydro chemical background, Coastal Aquifer, Krishna delta*

Paper ID – 027

## Study on subsurface hydraulic conductivity and soil moisture using Ground Magnetic Resonance (GMR)

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### Abstract

The ground magnetic resonance (GMR) equipment is working on the principle of magnetic resonance sounding (MRS). GMR equipment measures the magnetic signal from the subsurface water molecules via surface loop. It is a non-invasive method for estimation of relative hydraulic conductivity, which represents the ratio of unsaturated to the saturated hydraulic conductivity. The hydraulic conductivity in the capillary fringe zone can be considered as saturated because water content in this zone is considered equivalent to the water retention curve in equilibrium state. Hydraulic conductivity is the function of water content in the unsaturated zone of the aquifer. In this study, an attempt is made to perform field experiment using GMR and simultaneous inversion can be carrying out for obtaining the results of relative hydraulic conductivity, water content and decay time. Also, laboratory experiments shall be performed for finding saturated hydraulic conductivity and particle size



distribution analysis. Finally, a relationship between unsaturated and saturated hydraulic conductivity shall be developed at different depths of subsurface.

**Keywords:** *Hydraulic conductivity; ground magnetic resonance; water content; decay time*

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Paper ID – 050

### **An approach to delineate groundwater recharge potential sites in Rajgarh District, Madhya Pradesh using GIS techniques**

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#### **Abstract**

The demand of fresh water is increasing rapidly in Rajgarh district due to urbanization and population growth. So in order to maintain continuous supply of water and to meet the future requirements of water in Rajgarh district of Madhya Pradesh, it is very necessary to maintain the long term sustainability, groundwater is very necessary. Different influential factors are considered which affects the groundwater recharge. These influential factors are rainfall, geomorphology, slope, land use land cover, soil, lineament, drainage density, and lithology of the area. In this study with the help of Arc GIS groundwater potential zone has been delineated and are classified in very low, low, medium and high potential zones. The influential factors are processed and integrated using the weighted overlay analysis in Arc GIS. Results of the study reveal high to moderate groundwater recharge potential is in approximately 27% area and 64% area is under moderate potential zone. Suitable techniques for Artificial Ground Water Recharge are suggested as per the existing sit requirements.

**Keywords:** *artificial recharge<sup>1</sup>; water harvesting<sup>2</sup>; weighted overlay analysis<sup>3</sup>*

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Paper ID – 054

### **MODFLOW, MODPATH and MT3DMS based simulation of groundwater flow and leachate transport from landfill**

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#### **Abstract**

This study presents an approach for simulation of three-dimensional groundwater flow in two-layer aquifer system developed using MODFLOW, MODPATH and MT3DMS models within the framework of GMS conceptual model. The model was developed to integrate the groundwater flow system, to identify a suitable site for landfill and to analyse the long-term effects of contamination from a landfill site. The study was applied to a hypothetical region. The model was first simulated for the distribution of head by MODFLOW in steady state condition. The zones of influence of all extraction wells in the study area were determined by MODPATH reverse particle tracking simulation for 20 years. The area was modelled for two different cases. In the first case, a suitable landfill site was proposed for that area without overlapping the zones of influences of extraction wells designated as W1, W2, W3, W4, W5 and W6. The transport of leachate concentration which is generated from the landfill was observed using MT3DMS simulation. The second case involved selecting the landfill site in a region having more probable interference with the zones of influence of an extraction well for 20 years. The minimum time required by array of particles to move from the landfill area to the nearest affected well was



found out using MODPATH forward particle tracking simulation. The distribution of leachate concentration was also found out using MT3DMS simulation for 20 years at an interval of 2 years. The well W1 was observed to most contaminated for a pumping rate of 100 m<sup>3</sup>/day. The leachate transport model was again simulated for different increase in pumping rates of wells and the contaminant concentrations were computed after 20 years. The results revealed that with increase in pumping rates, concentration increases and obtain its peak in the well W1 which is most affected by contamination and nearer to the landfill region. After attaining peak, there is a gradual decrease in concentration with further increase in pumping rates. But in the other wells W2, W3, W4, W5 and W6 which are located gradually far from the landfill site, the concentration increases with increase in pumping rates.

**Keywords:** MODFLOW; MODPATH; MT3DMS; landfill; leachate.

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Paper ID – 061

## Hydro-Chemical Characterization and Quality Appraisal of Groundwater using Water Quality Index in District Jaipur, Rajasthan

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### Abstract

The study aims to assess the hydrochemistry of groundwater and its suitability for drinking purpose for district Jaipur. Groundwater quality parameters data of 196 locations in the study area were collected and analyzed using Gibb's plot and Piper Trilinear diagram. According to Gibbs diagram, based on TDS and the concentration of cations and anions; the predominant samples fall in the rock-water interaction dominance and evaporation dominance. Higher Cation ratio suggests that dissolution of silicate minerals is the dominant controlling factor of the groundwater chemistry of the study area. Piper's diagram classification shows that majority of the samples belong to Na-HCO<sub>3</sub> and Na-Cl-SO<sub>4</sub> hydrochemical facies, GIS based Inverse Distance Weighing (IDW) interpolation technique was used to signify spatial variation of water quality index (WQI) in the study area. Analysis of WQI reveals that Majority of samples belong to excellent to good water type (13.78 % and 45.41 %, respectively). The water samples within poor quality, and very poor quality contributed 33.16 and 6.13% of groundwater samples and can be used for drinking with some treatment and conventional disinfection, whereas Water "unsuitable for drinking purposes" covers only 1.53 % of groundwater samples could only be used for aquaculture, irrigation, and industrial purposes. The Spatial distribution map of water quality index shows that excellent quality found in the North Western and few patches in central part of the study area, due to high elevation area having less dissolution and infiltration, god water type identified in north, north-east and central part., poor and very poor water qualities were found in the south and south-west and few patches in central part of the study area and water unsuitable for drinking purpose observed in block Dudu and Phagi, located in southern part of the study area are unsuitable for drinking purpose.

**Keywords:** hydrochemistry, chemical classification, Gibbs diagram, piper diagram, WQI

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Paper ID – 079

## Development of an efficient methodology for improving ground water recharge by Hydrus 1 D

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### Abstract

Groundwater table is decreasing day by day. In the last two decades the groundwater table is decreasing in many parts of the world due to human activity. The over exploitation and unplanned pumping from aquifer is emerging as a serious concern. To prevent a future water crisis and to make water available in the areas which are already water scarce, this study attempts to plan for conservation of water. The best place to conserve water would be in the aquifers as these are already present naturally and are not affected much by man-made pollution. To conserve water in the aquifers we have to recharge them with rain water. One of the simplest and cost effective ground water recharge structure is the percolation pond or tank which falls in the category of surface recharge structures. Before reaching the aquifer the water travels through a partially saturated zone called the vadose zone. In this study, characteristics of the flow of water in the vadose zone below a pond are studied with the help of Hydrus 1 D software with the aim of optimizing use of rainwater in filling up of ponds and also finding ways of faster recharge of groundwater. It is seen that having a number of small ponds is advantageous for faster recharge of ground water. It is also found that Hydrus 1 D software can be used to decide up to what level ponds should be filled up for most efficient use of rain water. Hydrus 1 D software can be used to design a system of ponds according to the rainfall of the area and the time in which we want the water in the ponds to reach the groundwater.

**Keywords:** Water crisis; conservation; pond; Hydrus.

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Paper ID –085

## Identifying contaminant sources in groundwater using Kriging based surrogate model and Particle Swarm Optimization

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### Abstract

Locating the sources of the contaminant in groundwater is crucial for efficient remediation design and water resources management. Source identification in groundwater is challenging as an aquifer is only perceived as contaminated when contamination is measured in one of the observation wells. Amongst the available techniques, the simulation-optimization approach is commonly used. However, this approach can be computationally expensive as the governing equations and boundary conditions are required to be solved numerous times in the simulation model. In this study, a Kriging based surrogate modelling (KS) approach is proposed which replaces the simulation model and thus reduces the computational cost to a great extent. The surrogate model is trained using a few samples from the simulation model. In this study, a mesh free model named Radial Point Collocation Method (RPCM) is used as the simulation model. The injection rates at the possible source locations for different stress periods are used as input and corresponding concentrations at the



observation wells are considered as output. The surrogate model is then linked with Particle Swarm Optimization (PSO) which minimizes the mean squared error (MSE) between the predicted and simulated

concentrations. The KS-PSO model is applied to a hypothetical case study. The results indicate that the KS-PSO model accurately predicts the injection rates at the possible source locations.

**Keywords:** Groundwater contamination; Point Collocation Method; Mesh free method; Surrogate modelling; Kriging; Particle Swarm Optimization; Source identification

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Paper ID -198

## Groundwater quality evaluation for drinking and agriculture use in Phagi block, Jaipur District

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### Abstract

This research aims to assess the groundwater quality at gram panchayat level for drinking and agricultural purposes in Phagi block of Jaipur district. In order to evaluate the physico-chemical characteristics of groundwater, 19 sampling stations were examined to understand the spatial and temporal variations using Geographical Information System (GIS) during 2012 to 2018. The suitability of groundwater for drinking purpose is evaluated with different parameters viz. pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total hardness (TH), Fluoride and Chloride. However, different water quality indices namely sodium adsorption ratio (SAR), sodium percent (Na%), permeability index (PI) and magnesium hazard (MH), were applied to evaluate the irrigation suitability of groundwater. A GIS-based Inverse distance weighted (IDW) interpolation method is used for preparation of thematic maps for different groundwater quality parameters. The spatio-temporal results reveal that groundwater is not suitable for drinking with respect to pH (alkaline), very hard water (up to 1165 mg/l), EC (up to 6400  $\mu$ mhos/cm), and very high TDS values (above 1000 mg/l) in most of the panchayat except in some parts of Mohanpura (842 mg/l), Chittora (867 mg/l) and Dabich (934 mg/l) during study period. Higher concentrations of fluoride (0.24 to 6.48 mg/l) and chloride (21 to 1886 mg/l) were also indicating groundwater contamination. Temporal change (2012 to 2018) shows that drinking water quality is deteriorating in most of the panchayats of Phagi, except northern part. Fluoride concentration also indicates the increasing trend in 25 panchayats out of 32 panchayats during the study period. Most of the panchayat falls in the suitable range for irrigation purpose based on SAR and PI values. On the other hand, Na% and magnesium hazard indices indicate that Phagi block falls in the unsuitable category as Na% values vary from 23.9 to 82.2 % (2012), 33.8 to 96.1% (2015) and 60.8 to 91.5 % (2018); however, MH values falls in the range of 56.52 to 87.88 % (2012), 26.15 to 89.80 % (2015) and 23.81 to 92.86 % (2018) in the study area. Spatio-temporal variation reveals that deterioration of groundwater quality triggering threat to public health hence immediate remedial action is essential.

**Keywords:** Groundwater quality; SAR; Permeability index; GIS; Phagi

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Paper ID -221

## Assessment of Groundwater Potential Zones using AHP Technique in Darbhanga District of Bihar

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### Abstract

Darbhanga district is situated in North Bihar. In this region, 80 % of the irrigation demand is met by groundwater though it has annual rainfall of about 1200 mm. The increasing population and industrialization are likely to overexploit the groundwater and day by day groundwater level is declining. Thus it is important to delineate the groundwater potential zones in the study area, so that better planning and management of groundwater resources can be done. In this study, groundwater potential zone of Darbhanga district in Bihar has been delineated using GIS based Analytical Hierarchical Process (AHP). The parameters, which contribute the groundwater are geology, soil, slope, drainage density, lineament density, geomorphology, land use and rainfall. The thematic map of these parameters have been prepared by using remote sensing, meteorological and geological data of the study area. Different weights have been assigned to these parameters depending upon the influence of that parameter on groundwater potential. Geometric mean of weightage of these parameters have been computed using AHP technique. All the thematic map has been integrated in ArcGIS. Groundwater potential zones have been classified into five categories, such as very poor, poor, moderate, good and very good. Based on the above data, the groundwater potential zones have been delineated and computed using AHP technique for these classifications. The groundwater potential zones are: Very Poor - 9.90 %, Poor - 25.73 %, Moderate - 36.95 %, Good - 25.41 %, and Very Good - 2 %.

**Keywords:** Groundwater potential zone; Darbhanga; Remote sensing; GIS; Analytic Hierarchy Process.

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Paper ID -241

## Investigation on submarine groundwater discharge (SGD) and Saltwater intrusion (SWI) zones along Mangaluru to Udupi coast

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### Abstract

Submarine groundwater discharge (SGD) is a complex hydrogeological phenomenon it describes the exchange of fresh and recirculated saline groundwater from coastal aquifers into the ocean. The increase of population and rapid changes in urbanization, industries in coastal areas, and the increase of population and rapid changes in urbanization, industries in coastal areas, and its release of sewage recharged into coastal groundwater. This outflow of the Contaminated submarine groundwater pathway for transport of various chemical substances such as nutrients, metals, organic compounds to the marine environment. Hence, the identification and flux quantification of SGD in coastal regions is important. The main focus of this study is the identification and potential mapping of SGD zones using archival research and field-based in-situ sampling along with Mangalore



to the Udupi coast. The field-based water sampling measurement of well water, pore water, and seawater have been done using Hanna multi-water quality parameter sensor instrument. The measured water quality

parameters are pH, EC, Salinity, TDS, Temperature, and DO. these parameters have been processed, interpreted, and mapped by using IDW and Topo raster interpolation tool using ArcGIS platform. From the results, it reveals that the SGD zones 1 to 7 have observed freshwater with lower groundwater table concerning Mean sea level (MSL) and higher GWL more than 7.5m concerning MSL and also less than 32PPT of salinity in pore water samples are susceptible to SGD. Similarly, Saltwater intrusion zones (SWI) 1 to 16 have observed higher water quality parameter values like EC (> 1000 uS/cm), Salinity (> 3 PPT), pH (> 7.6), TDS (> 800), and temperature (> 29) along with the lower value of DO (< 3 mg/lit) indicate the traces of seawater intrusion. The complete assessment of salinity and electrical conductivity is cited in the result.

**Keywords:** SGD zones, SWI zones, In-situ measurements, GWL, IDW and Toporaster, Porewater, EC, Salinity.

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Paper ID -242

## Surface Water Groundwater Interactions in Estimating Groundwater Recharge using Genetic Programming

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### Abstract

Groundwater constitutes a significant part of the water resources required to meet the global water demand. Unweighted usage with added uncertain climatic conditions have depleted many groundwater resources making it unsustainable for future exploitation. Groundwater depletion is one of the biggest threat to humanity's sustenance and require proper management strategy. For long groundwater has been considered as separate resource. It is well established, that groundwater continuously interacts with surface water, water mass being exchanged between the two under different hydrogeological and hydrological stress conditions. These interactions happen on small scale to over regional scale. Even the time scale of these interactions can vary from a few hours to several decades. Therefore, effective water management must consider surface water and groundwater as "connected" single resource. Proper groundwater management of an aquifer requires accurate estimation of groundwater recharge. There are many direct and indirect methods and sophisticated models for estimating recharge. However, most of them require many field data or model parameters, which limit their actual field application. In this study groundwater interaction in estimating recharge is presented for a semiarid climatic region which gets recharged from high storm events using Genetic Programming. Genetic Programming (GP) as an Artificial Intelligence tool for predicting groundwater level fluctuations helps us to predict future groundwater recharge for various storm events. Only when the antecedent conditions are ripe a rainfall event results in groundwater recharge. A large portion of the precipitation infiltrates into the ground and gets consumed in raising the moisture content of the soil column above the water table until saturation. Storm events that result in groundwater recharge are looked at for both diffused recharge (directly falling on the ground surface) and focused recharge (indirectly as runoff to lakes, streams and rivers) for varying antecedent conditions. Precipitation in the upstream region results in diffuse recharge and also contributes to focused recharge in the downstream region through runoff in stream. The GP models are trained using large number of realizations of rainfall and stream flow fluctuations for differing input variable scenarios. Rainfall data from both upstream and downstream regions, groundwater level data from various boreholes, stream stages and antecedent soil moisture index is used for training the GP model. These evaluated results show efficiency in predicting groundwater recharge for storm events at different hydrogeological time scales.

**Keywords:** Groundwater management; Groundwater Recharge; Genetic Programming; Focused Recharge; Diffused Recharge; Antecedent Conditions

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Paper ID -251

## Effect of heterogeneity and anisotropy on enhanced spreading in porous media during Engineered Injection and Extraction

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### Abstract

Enhanced spreading in porous media is a topic of current interest for researchers working in the area of in-situ groundwater remediation. Spreading in aquifers takes two main forms, viz., passive spreading that takes place as a result of inherent heterogeneity or anisotropy of the aquifer, and active spreading that are induced by time varying flow fields generated with the aid of external forces. Engineered Injection and Extraction (EIE) is a novel method of active spreading which is used to enhance the spread of reagents within an aquifer during in-situ groundwater remediation. This method enhances the spread of reagents in aquifers by stretching and folding of contaminant reagent interface through flow perturbations created from the sequential injection and extraction of fresh water in wells around the treatment area. This work investigates the combined effect of active and passive spreading in porous media through three-dimensional numerical simulations using Visual Modflow Flex, a groundwater modelling software. The behaviour of a contaminant reagent interface during EIE is examined by varying the hydraulic conductivity values in three-dimension and thus incorporating heterogeneity and anisotropy. The simulation results showed significant enhancement in spreading when EIE was applied to a three-dimensional, anisotropic, heterogeneous porous media compared to a similar homogeneous, isotropic porous media. It was found that contrast in hydraulic conductivity because of heterogeneity and anisotropy plays a key role in enhancing the spread during EIE.

**Keywords:** EIE; Active and Passive spreading; Aquifer; Heterogeneity; Anisotropy

Paper ID -315

## A review of evolutionary algorithms in inverse modelling for groundwater flow and transport parameter estimation

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### Abstract

The groundwater flow and transport model prediction accuracy highly relies on the ability to accurately and reliably quantify parameters such as transmissivity, hydraulic conductivity, longitudinal and transverse dispersivities, storativity and areal recharge. Consequently, an important component of groundwater flow and contaminant transport model is the solution of the inverse problem, i.e. the estimation (identification) of groundwater flow and contaminant transport model parameters. When compared to the trial and error method, the time required for inverse solutions are substantially less. Simulation-optimization (S-O) models are extensively used in previous studies to assess aquifer parameters by inverse modeling (IM) approach where the groundwater flow and transport processes are simulated by Mesh Free (MFree) method, Finite Element (FEM),



Finite Difference (FDM), Boundary Element and Analytical Element Methods. In the solution of the inverse problem, the forward problem is solved many times till the unknown parameters are optimally calculated. Many heuristic optimization algorithms, such as Genetic algorithm-GA, Differential Evolution-DE, Particle Swarm Optimization-PSO, Ant Colony Optimization-ACO, Cat swarm optimization- CSO have been used for aquifer parameter estimation by inverse modeling. The heuristic optimization methods do not require derivative calculations or a well thought out initial point to start the search process unlike traditional gradient based methods. Lesser chance of getting trapped in a local optimum and having a higher probability to find a near-optimal solution as compared to conventional optimisation methods are other advantages reported of these evolutionary methods. In this paper, an attempt is made to review the applications of recent heuristic optimization techniques like GA, DE, ACO, PSO and CSO in parameter estimation problem considering the advantages and challenges while applying them in inverse modeling. Here, an application of DE for a hypothetical case study is also demonstrated for the parameter estimation of transmissivity in a confined aquifer.

**Keywords:** Groundwater parameter estimation, Inverse modeling, Heuristic optimization algorithms

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Paper ID -320

## Gravity wave dissipation due to multiple porous structures

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### Abstract

In the present study, the oblique wave transformation due to the multiple porous breakwater system is analysed. The proposed breakwater is a combination of vertical porous blocks and vertical barriers. Different structural configurations of the porous breakwaters are considered for the study and it includes porous blocks associated with (a) fully extended vertical barriers (b) surface piercing barriers and (c) bottom standing barriers. The study considers the finite spacing between the porous structure and barriers for better wave trapping and the Darcy's law is followed for the flow through porous media. The linear wave theory is adopted and the velocity potentials for the multiple porous regions and open water regions are developed. The edge conditions at the interfaces of vertical barrier and porous structure are considered and the Eigen function expansion method is adopted to determine the wave reflection/transmission characteristics. The complex dispersion relation proposed by Sollitt and Cross (1972) is adopted to incorporate the resistance and reactance offered by the porous media. The study shows a significant increase in wave energy damping with the increase of structural porosity. Further, the formation of standing waves in the confined spaces results in achieving a global minima of wave reflection coefficient.

**Keywords:** Eigen function expansion method; Reflection coefficient; Transmission coefficient; Wave force, Darcy's law; Vertical barrier

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Paper ID -322

## DISSIPATION OF GRAVITY WAVES DUE TO SUBMERGED POROUS PLATE AND BOTTOM STANDING POROUS STRUCTURE

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### Abstract

The present study deals with the wave trapping by a combination of submerged horizontal porous plate and bottom standing porous structure of finite width. The thickness of the plate is negligible when compared to the incident wavelength and water depth. The study is performed based on the Eigen function expansion method and the linearized wave theory is used to examine the wave interaction with the combined structure. The mode-coupling relation is considered to analyse the wave interaction with the combined structure. The reflection coefficient, transmission coefficient, dissipation coefficient, wave force on the submerged porous plate and the bottom standing porous structure is analyzed. The effect of change in the values of porosity and friction factor of bottom standing porous structure, submerged depth and angle of incidence on the present breakwater configuration are studied. The results obtained are compared with the results of available configuration in the literature in order to analyze the efficiency of the proposed configuration.

**Keywords:** *Submerged horizontal porous plate; Bottom standing porous structure; Reflection coefficient; Transmission coefficient; Wave force.*

Paper ID -369

## Prophecy of ground water using hybrid ANFIS-FFA approaches at Kalahandi watershed, India

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### Abstract

Accurate and reliable prediction of fluctuations in groundwater level (GWL) is imperative in water resources management and planning. Applications of fuzzy-logic techniques and Artificial Neural Network (ANN) to a variety of issues are found to be efficient. Recent surge in interest in aforementioned techniques has resulted in robust calculating techniques. Present study explores potential of three data driven models viz., Adaptive Neuro-Fuzzy Inference System (ANFIS), ANN, and a combination of firefly algorithm (FFA) with ANFIS for forecasting of GWL at Kalahandi, India. In this watershed, overexploitation of groundwater, and its management demands complete know-how of the groundwater flow dynamics. Yet, the groundwater flow dynamics is changing continually owing to human and climatic effects, and groundwater system is very complex, including several non-linear and uncertain elements. The monthly GWL data from the year 1990-2009 are used for training, while from the year 2010-2019 are reserved for testing. Using statistical measures, predicted data from hybrid model is compared with ANN and ANFIS model. Statistical indices applied in the analysis were Nash-Sutcliffe Efficiency (NSE), root mean square error (RMSE), Wilmott index (WI). The results showed that all three proposed models can forecast GWL with fairly high accurateness; however, ANFIS-FFA model can be a promising tool for simulating and forecasting GWL because of relatively smaller



RMSE. Also results reveal that ANFIS-FFA and ANFIS models provide superior accurateness (RMSE = 0.02654, 0.03623 and WI = 0.9763, 0.9583) followed by ANN model with (RMSE=0.06432 and WI=0.9042) for estimating GWL well in advance for proposed location.

**Keywords:** *Neural network; hydrology; groundwater level; ANN; prediction*

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Paper ID -417

## **Impact of Climate Change on Groundwater Recharge**

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### **Abstract**

Groundwater is an important natural resource for its use in domestic, agricultural, industrial and various purposes. Due to increase in population its demand is also increasing by each passing day. Though in India, surface water availability is more than ground water but as the later can be accessed more easily and widely, it is extracted more leading to decrease in ground water table by each passing day. Climate change also has a severe effect on groundwater. Increase in atmospheric concentrations of greenhouse gasses leads to change in hydrologic cycle through evaporation, soil moisture, precipitation with increasing temperature. So, along with growing population, climate change leads to inadequate recharge of groundwater thus resulting in declined groundwater levels. Thus, it is very important to predict the impact of climate change on future groundwater recharge. General Circulation Models (GCMs) are the main tools that gives fairly precised climate data on global or regional scale and have the ability to simulate present climate and predict changes in climate in future caused due to increased greenhouse gas concentrations. Therefore, this study aims to evaluate long term average annual groundwater recharge (2000-2019) based on the given scenarios of 2000-2019 and predict future groundwater recharge (2050-2059). A hydrological model, WetSpass is used for estimation of groundwater recharge and its spatial variation and future atmospheric conditions are predicted by downscaling climate data (precipitation, temperature and windspeed) from two CMIP5 GCMs (MIROC-ESM-CHEM and GFDL-CM3) under four RCP scenarios (2.6,4.5,6.0,8.5) using SD-GCM V2.0. The results of this study are expected to help in future planning and management of groundwater resources and to take suitable and necessary measures due to climate change impact.

**Keywords:** *Climate change, groundwater recharge, GCMs, WetSpass, SD-GCM V2.0*

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Paper ID -425

## Appraising Prolific Zones of Groundwater in hard rock phreatic aquifers from sub-watersheds of Upper Bhima Basin, Western India using Geospatial and MIF techniques

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### Abstract

A study on sub-watersheds of upper Bhima river basin namely BM-7,8,9,12,17,18,26,27,34 and 35 covering an area of 2360 sq.km was performed to decipher the potential groundwater zones. In remote and hilly areas, groundwater is considered as the primary source of water for drinking along with agricultural practises. The need for sustainable management of this resource is on rise due to the increase in demands. In the field of hydrogeology there has been a sudden breakthrough in exploring the subsurface water resources with the help of potentiality map. Keeping this in view, a prolific groundwater zonation map is prepared by applying the geospatial and Multi-Influencing-Factor (MIF) techniques. Various themes such as geology, geomorphology, slope, land utilization pattern, drainage and lineament densities, soil type and rainfall were considered as influencing factors and raster layers of the same were generated using satellite imageries and topographic sheets. MIF helps in assigning appropriate weightages and ranks to thematic layers and their feature classes that make some impact on groundwater occurrence. The map obtained by overlay analysis has been grouped in 5 classes from poor to excellent groundwater potential. This potential zonation map helps in planning and steady state development of this precious subsurface resource for efficiently meeting the future needs.

**Keywords:** Groundwater, basaltic aquifers, GIS, MIF, western India

Paper ID -430

## Estimating confined aquifer parameters using particle swarm optimization technique

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### Abstract

Groundwater management is an important part of the water resources planning and management. The transmissivity (T) and storage coefficient (S) of the aquifers control the movement and extraction of groundwater in the geological formations. These hydraulic parameters of the aquifers, which are key inputs for groundwater modeling and management, widely estimated using pumping tests. After obtaining the time-drawdown data from pumping test results, the parameters of the aquifer system are traditionally determined by means of manual curve matching approaches. Although these approaches are simple to employ, some errors might be introduced since the accuracy of these approaches is mostly dependent to the modeller's ability. Therefore, use of the simulation-optimization models becomes popular tools to determine the aquifer parameters. The purpose of this study is to develop algorithm using Particle Swarm Optimization (PSO) technique to estimate the aquifer parameters T and S and its fitness is checked by Sum Squared Error (SSE) of observed and simulated drawdown. The drawdown is simulated using Theis function. The model is tested with results of curve matching technique (Todd and Larry 1980). The SSE obtained by PSO optimized parameters is



found less than that obtained using Curve matching. In this study, the PSO algorithm is selected due to its strong search ability, fast convergence speed, and high efficiency.

**Keywords:** *Confined aquifer, Aquifer parameters, Theis function, Particle Swarm Optimization (PSO)*

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Paper ID – 495

## **Modelling and Mitigation of Salt Water Intrusion in Coastal Aquifers Using SEAWAT: A Review**

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### **Abstract**

Saltwater intrusion is the instigated stream of ocean water into fresh water springs. Saltwater intrusion can occur either due to natural processes, mainly due to lack of natural replenishment from rainfall, or the over-extraction and unplanned exploitation of groundwater from the coastal aquifers. The higher demand for freshwater emphasizes the importance of properly managing these aquifers and preventing saltwater intrusion by over-extraction. Numerical modeling is the most effective tool that hydrologists use to puzzle out and anticipate how saltwater intrusion occurs in coastal aquifers. The numerical models are based on the governing equations of groundwater flow and solute transport. One such numerical model is SEAWAT modeling, a three-dimensional variable-density groundwater flow and transport model that uses GMS as a pre - and post-processor. SEAWAT model integrates MODFLOW and MT3DMS in a groundwater modeling system (GMS) environment. This paper provides an overview of the use of SEAWAT on the quantification of saltwater intrusion in coastal aquifers, the status of research studies carried out, and the methodology to assess the impact of saltwater intrusion in coastal aquifers.

**Keywords:** *Saltwater intrusion, SEAWAT, GMS, Numerical modelling.*

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**THEME- V**  
**HYDRAULIC STRUCTURE AND HYDROPOWER**  
**ENGINEERING**



Paper ID – 005

## FLOW PATTERN AROUND MULTIPLE VANE ARRANGEMENT

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### Abstract

Submerged vanes are the foils placed skewed to the flow direction and are utilized to manage the sediment by altering the shear stress on the bed by generating the secondary currents on account of pressure difference between the two sides of vane. The range of angle of attack at which submerged vanes can be placed in the flow with respect to flow direction varies in between 10° to 40°. Since, there are few studies which consider non-rectangular submerged vanes but mostly with single tapered vane. Thus, present study studies the optimization of tapered vanes arranged as a vane pair and multiple vanes per rows. Numerical modelling of present study was done in ANSYS-CFX software using K- $\omega$  turbulence closure model to simulate the vortical flow. In present study it was observed that due to high vortical interaction for  $\delta_n = H$  &  $2H$ , the vane is not able to work independently with one vane vortex suppressing another one's while for  $\delta_n = 4H$ , the vanes induced the vortices individually and made a more efficient system.

**Keywords:** Secondary currents, Tapered Vanes, Ansys-CFX, Computational Fluid Dynamics.

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Paper ID – 024

## Study of Energy Dissipator with Different Blocks to Reduce Basin Width and Trajectory: A Review

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### Abstract

One of the most powerful and cost-effective strategies for dissipating hydraulic energy from flood waters is to project the flows into a free trajectory jet shape to a position where the impact produces a downstream river bed dip pool. If take-off speeds are increasing, ski jumps are standard features of dam spillways for efficient energy dissipation. A significant result of the Froud No. range approach flow, the relative height of the bucket and therefore the angle of the device is found. Using a physical hydraulic model, energy dissipation by a ski-jump can be assessed by evaluating several identified contributing parameters. Important parameters include; 1) Geometric water jet trajectory profile such as distance of trajectory, trajectory height, horizontal and transverse impact width; 2) Distribution of dynamic impact pressure; 3) average dynamic head of impact; 4) head of impact velocity; and 5) air entrainment. Deflectors are the element that is provided at the outlet to deflect the trajectory into a plunge pool area where sound rock is present so that less erosion occurs.

**Keywords:** Energy dissipation, Kinetic turbulence, Ski jump, stilling basin.

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## Hydraulic modelling of headpond with lateral spillway weir structure for the Tamakoshi-V hydroelectric project, Nepal

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### Abstract

The proposed operation of Tamakoshi-V hydroelectric project (TKVHEP), Nepal is completely determined by the discharge released from the power plant of Upper Tamakoshi hydroelectric project (UTKHEP), which led to the diversion of discharge from the already existing tailrace race tunnel (TRT) of UTKHEP to the interconnecting tunnel (ICT) that connects the said TRT and the headpond of TKVHEP; the flow in the TRT, the ICT, and the headpond being open-channel flow. Initially, the size of the headpond and the adjoined lateral spillway weir of TKVHEP were tentatively adjusted meeting the submergence criteria of the intake. However, in order to optimize the headpond size, the other criteria have been fixed by modelling the headpond reach (from the outlet point of the UTKHEP to the end of the headpond) using a physically-based and one-dimensional numerical model. The maximum discharge from the UTKHEP plant is  $Q_{max} = 68\text{m}^3/\text{s}$ . The normal depth of flow from the established hydraulic model corresponding to this discharge at headpond end has been observed at El.1155m, which is also the lowest regulated water level (LRWL) in the headpond, thereby meeting the intake's submergence criteria. Furthermore, the backwater development at the headpond due to sudden closure of TKVHEP plant and the propagation of wave towards the power tunnel have been modelled by considering the upstream boundary condition as constant discharge  $Q_{max}$  and the downstream boundary condition as transient flow at the headpond location in the model, which is based on the results of surge analysis (separately conducted) of the pressurized water conductor system of the TKVHEP. With the applied boundary conditions, the modelled headpond reach has been iteratively simulated, thereby changing the headpond dimensions and the crest length of the lateral spillway weir for each run. The crest level is fixed at El.1158.1m (0.1m above the recommended highest regulated water level, HRWL = El. 1158m) in the headpond. From the optimized model results, the maximum stage at headpond is observed at El.1159.1m and the design discharge through the lateral spillway weir has been deduced as the sum of inflow  $Q_{max}$  and the maximum transient flow opposite to the direction of inflow.

**Keywords:** TKVHEP; UTKHEP; TRT; ICT; headpond; open-channel flow; lateral spillway weir; transient flow; pressurized water conductor system; surge analysis

## Causes and Ecological Impact of Embankment Breaching in Dhemaji District

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### Abstract

Water, that is known as the lifeline of Human life sometime turns out to be so cruel that it takes away life of thousands of flora and fauna along with huge damage and loss of property thereby causing a catastrophic disaster called flood. One of the prime reason of this flood in the district of Dhemaji in Assam, India is embankment breaching. In this paper the causes and ecological impact of embankment breaching that caused about 98% of flood in Dhemaji is studied in detail. A door-to-door social survey and past reports of breaching since 1985 were scrutinized. The failure mechanism, soil characteristic, geometry and construction method of



the embankment in the district was thoroughly examined and analysed. It was found that embankment beaching in Dhemaji is primarily due to erosion (45%), overtopping (25%), seepage/pipping/boiling (5%), sudden failure and slump down (13%), cut by people (8%) and some other reasons like blockage (4%). The reasons behind these causes of breaching were identified as use of under quality embankment materials, lack of protective measures, rise of river bed, decrease in discharge and widening of river width, sudden high water thrust, deforestation in upstream watershed, jhum cultivation in hills, rise of stone quarries and people encroaching towards the river. A total number of 90 embankment breaches since 1985 in Dhemaji has adverse ecological impact on the locality. Impact assessment carried out by social survey for recent embankment breaching in the year 2017 divulges that besides imbalance in the lifecycle of wild flora & fauna, 58 villages with 23860 populations, 3715 hectares of cultivated area, 6895 large animals, 2278 small animals, 9054 poultry were affected; about 1360 houses were partially damaged, 27 kutchha houses were fully washed away in that particular year only. Thus, it is recommended to stabilize the embankment material by using bio-enzymes. Laboratory tests with and without bio-enzymes are to be conducted for different soil properties like gradation, compaction, strength, permeability, atterbergs limits etc. to confirm soil stabilization. To determine the soil stability and seepage analysis, finite element modelling may be done; thereby develop a flood resilient embankment system.

**Keywords:** *Flood, Embankment Breaching, Impact Assessment*

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Paper ID – 075

## **TURBULENT FLOW CHARACTERISTICS AROUND GROUP OF CIRCULAR BRIDGE PIERS OVER PLANE RIGID BED**

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### **Abstract**

Scour is the major cause for bridge failure all around the world. There are various factors that play important role in generation of scour hole, such as pier design (shape, size) and flow conditions (velocity, depth). Downward flow in upstream of the pier is the force that initiates scour generation. Strength of this downward flow can be reduced if; a) flow velocity is reduced, and b) pier surface area of water projection is reduced. In this study, surface area of projection has been taken into account. In order to reduce the surface area of projection, a single circular pier can be replaced with a group of circular piers of smaller diameter. Various pier arrangements can be adopted for experimental study. In this study, experiments for various flow conditions have been performed with three-circular-pier group. The piers are arranged as an equilateral triangle with single pier in the upstream and the face-to-face distance between the piers equals to the diameter of the circular pier. Velocity data are collected using Particle Image Velocimetry (PIV). Considering the maximum obstruction width across the flow, which is 10% of flume width; pier group of 0.05 m diameter piers were used, so that the maximum obstruction width lies within permissible value. The results from the study show the hydrodynamics leading to scour for group of piers and its effectiveness.

**Keywords:** *Turbulence Characteristics; Circular pier; Pier group; Plane rigid bed; PIV.*

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Paper ID – 076

## Stage Discharge Relationship by Weir Theory for Channel Flow Measurements Using the Conical Central Baffles

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### Abstract

The paper presents the use of weir theory to develop mathematical form of stage – discharge equation for measurement of flow in small rectangular open channels using conical central baffle flume. The flume is formed by placing a conical baffle axially in open channels which is mobile in nature and hence can be used for temporary flow measurements. The channel cross-section reduces around the central baffle and reaches its minimum at its central section. For this section, the discharge equation for the trapezoidal weir with crest height equal to zero can be used for flow measurement. The coefficient of discharge ( $C_d$ ) in the weir discharge equation is expressed in non – linear form as function of apex angle of cone, contracted channel width and the upstream flow depth, to correct the nonrealistic assumptions. The empirical coefficients in the non – linear form of  $C_d$  is determined by minimizing the summation of the absolute relative errors of the flow discharges, using the experimental data collected on laboratory flumes. The presented approach for discharge prediction is compared with an analytical approach available in literature in which the stage – discharge relationship for the conical central baffle flume is derived using the energy concept. The average absolute error is found to be 3.55 % using the weir theory as against 4.24 % using the analytical approach for the same experimental data. This suggests that the weir theory can also be applied to predict discharge for the conical central baffle flume provided the coefficient of discharge should be determined by the developed non- linear form.

**Keywords:** Conical Flume, Flow measurement, rectangular channel, Central baffle, Weir theory,

Paper ID – 082

## Study on Aeration Performance of P.K. weir with its Alternatives: A Review

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### Abstract

Aeration is the phenomenon by which air is mixed with or dissolved in a liquid. Proper aeration over the hydraulic structures mitigates the risk of cavitation and is used in maintaining the required Dissolved Oxygen (D.O.) concentration in the flowing water. In the open channel, the nappe's upper surface is exposed to the atmosphere, whereas the nappe's lower surface is sometimes fully or partially submerged. Therefore, the lower surface of the nappe must be sufficient to ensure the proper aeration. The loss of the D.O. concentration in a stream or open channel flow due to the increment of salt concentration, the increment of the temperature of flowing water, and the increment of cavitation effect can be remedied by enhancing the aeration performance of the weir structures. There are many ways to improve D.O. concentration in water using self-aeration, mechanical aeration, chemical aeration, or hydraulic structures. However, the hydraulic structures used for aeration are weirs, notches, water jets, spillways, hydraulic jump, falls and close conduit flow arrangements, etc. In the last decade, several studies have explored the aeration performances of the different types of free-flow structures such as rectangular, triangular, trapezoidal, semi-circular, labyrinth, and Piano key weirs. This study



reviews the past studies on the aeration performance of the different types of weirs such as rectangular, triangular, labyrinth weir, and P.K. weirs. A closer look at the review shows that the P.K. weir has an excellent aeration performance to mitigate the risk of cavitation and is used in maintaining the required Dissolved Oxygen (D.O.) concentration in the flowing water over the hydraulic structures.

**Keywords:** *D.O. Concentration, Aeration, P.K. weirs, Aeration efficiency over different weirs.*

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Paper ID – 103

## STUDY OF FLOW CHARACTERISTIC OF RECTANGULAR LABYRINTH WEIR

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### Abstract

A rectangular labyrinth weir is characterized by a broken axis in plan as is seen in so that the effective length of crest is increased. This accounts for the spatial flow behaviour and defines the water surface profile along with the centre line of the labyrinth weir upstream channel. A physical model for the experimental studies design and analysis of rectangular labyrinth weirs. Hydraulic model tests of the weir showed that the behaviour of the labyrinth weir was convenient and that the discharge capacity presented a good agreement with theoretical calculations. It is the purpose of this paper to present a satisfactory developed physical model of labyrinth weir flow and provide engineers with a model capable of dealing with a variety of labyrinth weir configurations and flow conditions. These studies of rectangular labyrinth weir are performed between head to crest ratio, apex width, vertical aspect ratio, approach and conveyance channel conditions that increased the discharge capacity of rectangular labyrinth weir and design of rectangular labyrinth weir.

**Keywords:** *Rectangular Labyrinth Weir, Hydraulic model, Physical model, Discharge Coefficient.*

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Paper ID – 110

## Hydrodynamic Cavitation: A Treatment to Secondary Effluent of STP to Reuse

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### Abstract

The degradation of secondary sedimentation tank effluent from the Sewage Treatment Plant (STP) using Hydrodynamic Cavitation (HC) for reuse has been investigated for the first time. The HC experiments has been designed for the study of HC process performance in Secondary Sedimentation Tank Effluent of Anjana STP, Surat, sampled for precised understanding of effect on inlet pressure (0.4 to 1.0 kg/cm<sup>2</sup>), the geometry of the cavitating device on reuse which was measured by COD parameter, has studied to maximize the rate of reduction of COD. The maximum reduction in COD as 64.12% for 2 mm hole is obtained under 0.8 kg/cm<sup>2</sup> optimized inlet pres sure. The pseudo-first-order kinetics has been used to described degradation. The hydrodynamic cavitation is zero sludge production, Physico-chemical treatment for SST effluent. The degradation COD has in the permissible limit for reuse the treated wastewater for various purposes like irrigation, plantation which helps to keep clean the environment.

**Keywords:** *Chemical Oxygen Demand, Orifice Plate, Reuse, Secondary Sedimentation Tank Effluent.*

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Paper ID – 148

## **New Methodology of Optimisation of Water Conductor System in Hydropower**

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### **Abstract**

Water conductor system in a hydro power projects conducts water required for generation of power from reservoir to the power house. The purpose of this study is to elaborate new methodology of optimisation of water conductor system in hydropower developed by a Practicing Engineer based on design experience and detail research carried out for verifying research output for a practical range applicable for major hydro power projects. The new optimisation methods of all the major components of water conductor system including intake, desilting basins, surge shafts and pressurised conduits are elaborated in this study. The optimisation of the desilting basins will be developed based on further studies carried out on the most read articles on the desilting basins on Google search engine published by the author. The optimisation of the tail race surge shaft published by the author and topped the list of Google Search Engine is taken as base to develop methodology for optimisation of surge shaft. The methodology of the optimisation of intake and tunnel are based on design experience of author. The optimisation methods suggested in this study will be useful in water conductor system optimisation and, hence, the cost of the hydropower projects can be minimized.

**Keywords:** *Hydropower; optimisation; methodology; water conductor system.*

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Paper ID – 165

## **Numerical Simulation to Study Cavitation Characteristics of Centrifugal Pump**

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### **Abstract**

Pumps are roto-dynamic devices used to enhance the energy of fluids. Centrifugal pumps are commonly used in water supply, irrigation and industries also. They are a common part of our day to day life. Their efficiency and performance is always an area of research. The performance of centrifugal pump depends on the operating conditions and cavitation characteristics of the pumps. In most of the cases the pumps capacity is determined by system head curve of the area where the pump is required to be installed. But in reality the pump hardly performs at best efficiency point. The performance of pump deteriorates at off design conditions which is mainly because of cavitation. Cavitation performance at off design conditions are required to be predicted before installation and commissioning of the centrifugal pumps. In present work numerical simulation of a radial flow centrifugal pump is carried out to study its performance in terms of efficiency and cavitation characteristics at constant rotational speed of 2900 rpm and 5 different discharge values which includes duty point and off design conditions. It is observed that as the pressure decreases in the suction side of the pump, losses at various parts of the pump increases, the increase in loss is more prominent in impeller and it increases with cavitation at suction side of the impeller.

**Keywords:** *centrifugal pump, cavitation, NPSH, cavitation coefficient, pump characteristics*

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Paper ID – 203

## Three-dimensional flow dynamics in a bend channel with scour protection as a combination of submerged vane and riprap

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### Abstract

Detailed study of three dimensional velocity data in a 180° bend with combination of submerged vane and riprap were done experimentally. Acoustic Doppler Velocimeter was used to measure the three components of instantaneous velocities at multiple cross sections in bend for scoured bed with combination of submerged vane and riprap. The three dimensional velocity data shows that the disruption of spiral flow due to the presence of a combination of vanes and riprap appears to play a major role in the modification of the scour pattern. Moreover, the installation of vanes and riprap at the outer bank of the bend influenced the magnitude and distribution of streamwise component across the sections. Basically, the placing of riprap does not cause any major change in the flow or vortex formation, the submerged vanes placed along the toe is mainly responsible for modification of flow pattern in presence of combination of vanes and riprap. The vane not only intercepts the cross-flow but also reduces the magnitude of the streamwise velocity component around it. Overall magnitude of streamwise component is reduced in the bend with its more influence at the outer bank and the scour is reduced by about 85%. The experimental results obtained from the present investigation can be used for validation of analytical works and also will be useful in efficient design of protection works at bends.

**Keywords:** Three-dimensional flow; channel bend; scour; protection; vane; riprap

Paper ID – 245

## Design of conservation measures in Palar river of Tamilnadu

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### Abstract

The average yearly rainfall of Tamilnadu varies considerably with space and time. The state is mostly dominated by north east monsoon and few portions of the district experiences rainfall during south west monsoon. The state has only seasonal flow rivers. Palar is one such river. It rises in Karnataka state after traversing briefly through Andhra Pradesh, the river enters Tamil Nadu at Vellore district and drains into Bay of Bengal. It flows about 350 km and confluence into the Bay of Bengal at Vayalur (12°29'9" N 80°7'55" E) near Chennai adjacent to Kalpakkam atomic power plant. The river basin area is 17871 km<sup>2</sup>. The river and adjacent areas have high ground water potential and is supplying drinking water to districts of Vellore, Kanchipuram and Chennai apart from supply to some selected industries like nuclear plant. In addition there is irrigation also taking place. The lower reach adjacent to confluence point south of Chennai is experiencing annual rainfall of about 1200mm while it varies to nearly 650mm in the upper reaches. The basin has about 25 rainfall days in a year. Hence it has become an inevitable task for the water resources engineers to evolve suitable conservation measures. Based on detailed studies, a weir of height of 1.5m with a dyke like penetration in to the subsurface sandy strata so as to minimize seepage was evolved. Suitable location were identified in the lower reach of river and the structure was installed. The details design and its post benefits are discussed.

**Keywords:** Rainfall, dyke, strata,



Paper ID – 247

## Effect of in-line spacing between twin bridge piers on the scour pattern

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### Abstract

Circular piers are most commonly used for bridges around the world. Depending on the width of the bridge, single or multiple piers are provided. When the number of piers is more than one, the scour pattern around the pier is affected by the mutual interference and the formation of the horseshoe vortex system around each pier. The mutual flow interference, due to the presence of multiple piers, and its effect on scour pattern depends on the spacing between the piers. Experimental studies were carried out in order to study the variation of scour patterns due to the effect of in-line spacing between two bridge piers embedded in a sand bed. Experiments were conducted in a recirculating flume, 0.3m wide, 0.6 m deep and 8.5 m long. The sand used as bed material was of size ( $d_{50}$ ), 0.8 mm. The diameter of the piers used was 0.03 m. First, experiments were done using a single circular pier, as a reference. Thereafter, experiments were carried out for twin circular piers, placed in-line in the flow direction. The spacing considered were once, twice and thrice the diameter of the pier. Experiments were carried out for five discharges ranging from 0.006 to 0.018 m<sup>3</sup>/s. The flow velocities were measured at different locations along the upstream and downstream side of the piers using acoustic Doppler velocimeter (ADV), which measures velocity components in streamwise, transverse and vertical directions. The duration of each experiment was eight hours to maintain consistency among the different cases. The velocities were measured after the stabilization of the scour hole. After 8 hours, the water was allowed to drain out and scour depths were recorded using a point gauge. There is considerable variation of flow pattern in the region between the piers. The results obtained shows that the maximum scour depth occurred at the upstream end of the pier. The value of the maximum scour depth was more or less the same for all cases with a maximum variation of 6%. However, there was significant variation in the scour pattern among all these cases.

**Keywords:** *Circular Pier, Horseshoe vortex, twin in-line piers, turbulence parameters, scour*

Paper ID – 260

## Seepage Analysis of Earth Dam based on Numerical Methods

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### Abstract

Earth dams are important hydraulic structures creating artificial reservoirs. Safety of earth dam mainly depends on its seepage aspects. Currently, it is possible to analyse seepage behaviour of earth dam effectively using numerical model which is very useful for formulating suitable controlling measures. To identify the reasons behind the seepage problems of earth dams, numerical modelling is conducted using ANSYS Fluent and GeoStudio. The GeoStudio software consists of a special tool SEEP/W, which is specifically designed for seepage analysis of earthen dams, gravity dams or similar structures where seepage is expected. In the case of



ANSYS Fluent, a Computational Fluid Dynamics (CFD) based software, there is no such specific tool for seepage analysis but its wide applicability in various flow conditions can be utilized effectively for seepage analysis also. Multiphase-volume of fluid viscous-laminar-porous model of ANSYS Fluent is utilized for the seepage analysis. Both the ANSYS Fluent and the GeoStudio models are validated and compared with the results from the literature. After validation and comparison, it is concluded that both this software can be effectively utilized for numerical modelling of earth dams having seepage problems.

**Keywords:** Seepage, Earth dam, ANSYS Fluent, GeoStudio, SEEP/W, CFD

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Paper ID – 295

### **Physical and Numerical Study for flow over Spillway Profile of Kiru Hydroelectric Project, J&K**

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#### **Abstract**

Flow over spillway was studied with physical model and the same was compared with numerical results obtained from the CFD analysis. Discharge, water surface and pressures were measured for various flow conditions. Computational fluid dynamics (CFD) program FLOW 3D was used to solve the Reynolds-averaged Navier-Stokes equations along with RNG turbulence closure model. Reasonable agreement was obtained between physical and numerical model results. The numerical model accurately reproduced discharge and water surface profiles. However, at few locations, significant difference in low and high pressure values was observed but it follows similar trend and magnitudes as observed in the physical model results.

**Keywords:** Spillway, Orifice, CFD, Discharge, Pressure, Water surface Profile

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Paper ID – 318

### **Hydrodynamic Performance of Array of Heaving Point Absorbers Combined with Stlp-Type Floating Wind Turbine**

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#### **Abstract**

In the present study, the numerical model in frequency domain based on the potential flow theory is considered to study the hydrodynamic performance of cone-cylinder type heaving point absorbers combined with Submerged Tension-Leg Platform (STLP). The arrays of heaving point absorbers are placed in circular and concentric pattern in different numbers to understand the performance of heaving point absorbers in absorption of wave energy. The study for the hydrodynamic performance is conducted for 8 heaving point absorbers in circular and concentric arrangement around the STLP platform. The cone-cylinder type heaving point absorber is selected for the study purposes as they yield more wave power as compared to other shaped point absorbers. The point absorber is assumed to have a linear power take-off system of external damping coefficient and supplementary mass coefficient tuning the point absorber. The presence of the Wave Energy Converters (WEC) around the platform affects the hydrodynamic coefficients (added mass, radiation damping and excitation force) and hence to illustrate the effects of WECs on the platform the ratio of hydrodynamic coefficients for a single WEC to those for a hybrid system is analysed. The study also compares the wave power absorption of each point absorbers around the platform in irregular waves for different sea-state conditions taking into account the North Atlantic wave data. The effect of incoming waves is also illustrated as the study is carried out for four



different wave heading angles. In order to quantify the performance, the q-factor and co-efficient of variance are compared for each array for different sea states. The study performed will be helpful in the design and analysis of possible arrangement of point absorbers around the wind turbine platform for wave power absorption.

**Keywords:** *Submerged Tension-Leg Platform (STLP); Wave Energy Converter (WEC); Potential flow theory; Hydrodynamic Coefficients; Point Absorber.*

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Paper ID – 321

## **Estimation of reservoir capacity of Singda dam, Manipur using modern Integrated Bathymetry System (IBS) - A case study**

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### **Abstract**

The Singda Dam is multipurpose project which is constructed across the Singda River and is one of the highest earthen dam in India. It has been catering the needs of drinking water and water for irrigation to most part of Imphal city and its nearby villages. The dam was built by National Projects Construction Corporation Limited (NPCCL) and completed in the year 1995. Since then, more than 25 year of operation, the project authority decided to conduct the bathymetry survey for evaluating the existing storage capacity of the reservoir and estimate the silt deposited. By evaluating the present storage capacity of the reservoir, the project authority can be planned the distribution of water supply for irrigation and drinking purpose. The study also includes finding the possible methods to enhance the dam water storage capacity by means of removal of silt from the reservoir. The CWPRS, Pune Instrumentation division team, carried out bathymetry survey of Singda dam during the month of Jan. 2020. The team deploying the modern Integrated Bathymetry System (IBS) at site consisting of echo-sounder sensor, DGPS with antenna mounted on a motorized boat with necessary fixtures and other auxiliary equipments and Laptop for data collection. This IBS system has depth accuracy in cms sub meters and position accuracy in sub meters. The bathymetric survey was done at an El 904.50 m. The data collection planning and analysis was carried out using software such as Hypack, Surfer. The Google earth and Global mapper software, was used for extracting survey area boundary of the reservoir. After the analysis was done the gross storage capacity of the reservoir is calculated and it was found that there was a substantial reduction in storage capacity of the reservoir during span of 25 years after its operation.

**Key Words:** *Bathymetry, IBS DGPS, Echo-sounder, HYPACK, Surfer.*

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Paper ID – 324

## DYNAMIC ANALYSIS OF ARRAY OF HEAVING POINT ABSORBERS COMBINED WITH SEMI-SUBMERSIBLE FLOATING WIND TURBINE

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### Abstract

The integration of Offshore Floating Wind Turbine (FWT) with Wave Energy Converter (WEC) helps in better use of the ocean space for renewable energy and also decrease the associated costs of installation and maintenance when compared to separate individual devices. One of the significant advantages of combined wind and wave-power generation is to improve the probability of continuous power supply, which had been the major criticism of renewable energy sources, by minimizing the interruptions and compensating power fluctuations of one with another. In the present paper, the combined concept of semi-submersible offshore wind turbine with different arrangements of Point Absorber-type wave energy converter is studied. The cone-cylinder shaped point absorbers are arranged in different numbers around the cylinders of the OWT to study the effect of point absorbers on the platform. The hydrodynamic analysis is performed using WAMIT, and the coupled dynamic analysis is performed using FAST to study the motion amplitudes, forces and bending moments at the tower base of the combined OWT and point absorber WEC configurations. Further, various configurations of the point absorber attached to the OWT is compared, and the best possible configuration is identified for the combined wave and wind energy device.

**Keywords:** *Semi-submersible platform; Wave Energy Converter (WEC); FAST; Offshore Wind Turbine; Dynamic analysis.*

Paper ID – 428

## Dam Break Analysis of Nagarjuna Sagar Dam Using HEC-RAS

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### Abstract

A dam serves multipurpose objectives like water supply, flood control, electricity generation, fishing, irrigation, and other requirements. Proper maintenance of a dam is a must, else the failure of which causes an aftermath which involves a sudden and uncontrolled release of water which is impounded. Due to which several dams in India accounting for more than 200 have failed, this being a reason causes importance for the focus on dam breaking analysis which includes break parameter prediction, understanding of dam break mechanics, and peak outflow prediction. In this study, an attempt is made to apply HEC-RAS to analyze the dam break analysis and to develop an inundation map, which forms an essential mechanism for the re-habitation process, helps to protect the loss of life and property before its failure. The Hydrologic Engineering Center's River Analysis System (HEC-RAS), RAS Mapper, and the ARC-GIS software are used to develop the dam break model. RAS Mapper is used to get the geometrical information about the study area and HEC-RAS is adopted to study the unsteady flow simulation, which uses the input data like boundary conditions, normal depth, breach parameter, and side slope. The inundation map which is obtained depicts the affected flood areas at the downstream and is



taken as a preliminary assessment of flood hazard. In this study, the dam break analysis is confirmed after comparing different formulas proposed by authors and finally, a flood hydrograph at the downstream, velocity and rating curve at critical points on the downstream for Nagarjuna Sagar dam are readout and documented.

**Keywords:** *Dam Break Analysis, HEC-RAS, HEC-RAS Mapper, ARC-GIS, Inundation map*

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**THEME – VI**  
**HYDROLOGIC AND HYDRAULIC MODELLING**



Paper ID – 035

## Mathematical model studies for construction of Temporary Pile bridge for erection of a Flyover bridge across an estuarine river

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### Abstract

Mumbai Metropolitan Region Development Authority (MMRDA), Mumbai has undertaken construction of an overhead Flyover Bridge, a connector across Mithi River just upstream of Mini Confluence, to link the area of 'G' Block and Mahim Nature park through Eastern Express Highway (EEH) as part of Mumbai Urban Town Planning (MUTP) Scheme to improve the traffic condition and accessibility to BKC at chainages 3.40 km from Mahim Causeway Bridge. On the basis of the studies conducted for the proposed Flyover Bridge at CWPRS in July 2014, the project authority accepted the proposal of 2.20 m diameter of Pier with minimum clear waterway width of 50 m having total length as 210 m. The present studies pertain to one dimensional mathematical model studies conducted to assess the effect on the hydraulic conditions due to the erection of Temporary Pile Bridge structure of 1.0 m diameter with 7.5 m c/c to be subsequently used to facilitate construction of Piers of the Flyover Bridge. The clusters of 28 Temporary Piles are proposed to be laid across Mithi River throughout the span of 210 m. The studies were carried out for unsteady state discharge condition in the model for rainfall event of 100-year return period with storm duration of 6 hours having Daily Maximum Rainfall of 570 mm based on analysis of latest Isopluvial maps of IMD. On simulation of Temporary Pile Bridge in mathematical model for four proposals as per the stages of construction of Piers, the maximum water level observed upstream of bridge location is (+) 5.66 m CD with marginal afflux of 0.01 m which is safe from hydraulic point of view.

**Keywords:** Temporary Pile Bridge, afflux, return period, Isopluvial, linear waterway

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Paper ID – 094

## Simulation of leaching process of Heavy metals in the vadose zone under wastewater application

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### Abstract

The continuous application of untreated municipal and industrial wastewater to land poses a major environmental concern. Contaminants leach through the vadose zone and may eventually lead to deterioration of groundwater quality. This study was carried out on a contaminated site in Laksar, Uttarakhand, India. The Hydrus 1D numerical modeling software was used to simulate solute transport in the unsaturated zone for the 10-year simulation period. In this study soil samples under wastewater application were studied up to 90 cm. Heavy metals (Cd, Cu, Zn, Ni, Pb) concentration in the wastewater was measured and given as an initial concentration on the soil profile. The trace metals concentrations were determined from each soil layer and compared with the simulated concentration after simulation period. Results from the simulations show that higher concentration of contaminants was accumulated in the top soil layer and gradually decreases along the unsaturated zone. Significant concentrations of heavy metals found in the bottom of the soil profile taken, which poses a risk of polluting shallow groundwater table underneath. Simulated values show a good agreement with the observed values with a coefficient of determination varies from 0.94 to 0.99 and index of agreement varies from 0.96 to 0.99. This study shows that Hydrus 1D model can be applied to determine the leaching process of heavy metals in the vadose zone and anticipate arrival time to a specified depth.

**Keywords:** Leaching; Hydrus 1D; Heavy metals; vadose zone



Paper ID – 120

## Rainfall-Runoff Simulation in Mahi Bajaj Sagar Dam Catchment, India, Using HEC-HMS

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### Abstract

Rainfall-runoff simulation is an essential step to estimate the hydrological process and the water resources availability for a reservoir. This can aid in water resource management and planning. Mahi Bajaj Sagar Dam is one of the major water resource projects in the Mahi Basin. This study uses the hydrological modeling system (HEC-HMS) for simulation of the Mahi Bajaj Sagar Dam catchment to analyze the response of rainfall and runoff. Rainfall-runoff modeling helps in estimating inflows, which is very essential to strategize water resources management. This model also incorporates ArcGIS extension HEC-GeoHMS which performs geospatial analysis and generates the hydrologic modeling inputs for the HEC-HMS model. SCS unit hydrograph method was used for runoff estimation. Daily precipitation data, temperature data, monthly evaporation data, elevation data and curve number, which take in to account the land use and soil characteristics of the watershed was used as model inputs for the HEC-HMS model. Then the calibrated model (period 2010-2014) was validated with data set of the period of 2015-2017. The performance of the models is assessed using different statistical indicators such as the Nash–Sutcliffe efficiency (NSE), Root mean square error (RMSE), Percent bias error (PBIAS) and the coefficient of determination ( $R^2$ ). The results show good relation with observed data. Thus, this study shows that HEC-HMS hydrological model can be used for rainfall-runoff simulation for long time period for reservoir operation planning and management.

**Keywords:** HEC-HMS; Rainfall; Runoff; HEC-GeoHMS; Reservoir Operation; LULC; ERDAS IMAGINE

Paper ID – 125

## Evaluation of Run-Off and Its Impact on Confluence of Tributary Due to Rapid Urbanization in Shipra River Basin

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### Abstract

Indore & Ujjain are the major towns in the Shipra River Basin and the same is experiences the flash flood every year. The Shipra River is a tributary of Chambal River. Around 20 no of towns and 1035 no of villages comes under this river basin. The Land use changes have been calculated over a period with satellite Image of Shipra River Basin and increase in built-up area has been calculated of urban and Rural area for Year 2000 and 2020. The complete catchment has been divided in eight parts. The runoff has been calculated with five-year return period and it has been observed that same has been increased drastically in 20 years. The flash flood received in tributary from urban area and rural area in the same time and flooding conditions created by River Basin. The width of the stream is fixed in some places and at some places has been encroached. Due to rapid urbanization, the time of concentration and lag time has been reduced drastically and value of runoff coefficient has been increased. The carrying capacity of streams is not sufficient to cater the complete flood and same is spread in the surrounding area. The flood affects the Urban property as well as agriculture. Now a day, the flood is happening in most of part of India. It is most important that complete river basin should be studied considering all factors i.e. Urbanization effect, agriculture area, etc. and same will help for the design of urban drainage.



**Keywords:** Land use, Urban Development, Runoff

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Paper ID – 168

## Water Quality Assessment using Probabilistic and Possibilistic measures – A Case Study

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### Abstract

Water quality assessment of surface water systems plays a key role in water resource management. Water quality is identified in terms of physical, chemical and biological parameters, which are highly uncertain in the spatio-temporal domains. Uncertainty associated with the parameters of water quality encompasses two aspects: one associated with the temporal values and the other vagueness in the definition. The emphasis of the present study lies in the assessment of water quality of a surface water body incorporating the uncertainty in the variables associated with its definition, using the concept of fuzzy random variable. With the two types of uncertainty considered, wherein the first type of uncertainty is incorporated by probability measure through probability distributions while the second type of uncertainty is considered by possibility measure, incorporated through fuzzy sets. The modelling procedure is illustrated for the Upper Klamath Lake, USA, to assess the water quality. The parameters are considered as random variable and interaction is considered as fuzzy variable. The catastrophe theory is also applied on the monitored data for dealing with the interaction between the parameters. The state and control variables of the catastrophe theory is measured based on complementation principle. The probability and possibility measure is done on the monitored data information of water quality. One factor assessment model is introduced to assess the water quality classification. The results of the proposed approach is the advantage of reducing the loss of water quality information. The study clearly illustrate the potential of measure theory in the assessment of water quality of a system.

**Keywords:** Water quality assessment, Fuzzy random variable; Catastrophe theory

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Paper ID – 186

## Mathematical Model Studies for Surge Analysis of Haldi Purani Lift Irrigation Scheme

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### Abstract

Lift irrigation schemes carry water by means of pumps from the water source to the main delivery chamber, which is situated at the topmost point in the command area from where water is laid to the distribution system. The capacity of pumps is fixed depending upon the duty point head and discharge. The main advantage of the lift irrigation is the minimal land acquisition and water losses. Lift irrigation schemes are useful where the distribution points of land are at higher level. The pressure transients often occur in lift irrigation due to power failure, pump start-up and shut-down operations, sudden valve closure and check-valve slam. CWPRS has taken up the hydraulic transient analysis of Haldi Purani Lift Irrigation Scheme, Maharashtra. The primary objectives



of surge analysis are to determine the transient pressures and to suggest surge control devices for an acceptable level of protection against hydraulic transients. The Haldi Purani Lift Irrigation Scheme project is located on the River Wainganga in Gadchiroli district of in Maharashtra. This scheme envisages lifting of water from River Wainganga by means of three vertical turbine pumps with rated discharge of 0.733 m<sup>3</sup>/s (each). Pumps were followed by a manifold, a rising main of 1.2 m diameter and 5.34 km length and a deliver chamber. The total static lift was 21 m. Based on the hydraulic transient studies of the rising main during power failure, protective devices in the form of air valves of ten numbers and air vessel of 150 m<sup>3</sup> capacity was suggested to control maximum and minimum transient pressure in the rising main.

**Keywords:** Pressure transients, Finite difference, Surge analysis, Transient control devices

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Paper ID – 189

## IMPACT OF DEEPENING OF APPROACH CHANNEL FOR NEW MANGALORE PORT – A CASE STUDY

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### Abstract

Under Sagarmala expansion plan, New Mangalore Port has proposed to deepen the approach channel in stages from -15.4 m to up to -20 m to cater to 180,000 DWT vessels. New Mangalore Port is a lagoon type harbour with a long approach channel artificially created by dredging. The Port is nestled between the Netravati and Gurpur rivers at location 12°57'17"N and 74°48'17"E in the state of Karnataka. The port is approached through a 7.5 km long channel with water depths in the outer channel being -15.4 m below CD and that of the inner channel being -15.1 m. The existing north and south breakwaters are approximately 770 m each which protect the lagoon area for safe handling operations as well as restrict the littoral drift and also provide the adequate stopping distance to ships. The prevailing depths in approach channel can cater vessels up to 90,000 DWT. Numerical model studies were taken up to predict the impact of deepening on hydrodynamics and sedimentation in the approach channel considering both wave and tide induced currents. Both hydrodynamics and sedimentation models were calibrated for prevailing currents and sedimentation in the approach channel and harbour area and model was simulated for proposed depths to predict sedimentation after deepening of the channel to different depths. The total annual maintenance dredging quantities for proposed deepened depths of -18.0 m and -20.0 m were estimated to be 7.8 Mm<sup>3</sup> and 9.2 Mm<sup>3</sup> respectively against the present quantity of about 6.2 Mm<sup>3</sup>.



Paper ID – 201

## Application of SCS-CN Method and HEC-HMS Model in the Estimation of Runoff of Machhu River Basin, Gujarat, India.

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### Abstract

The runoff estimation process is extremely complicated, nonlinear, and dynamic in nature which depends on the physical factors and meteorological conditions. The spatial changeability of these components causes more vulnerability in the parameterization of the model. Nowadays, with the help of remote sensing and GIS technology, it is possible to identify, assess, and understand the response of the dominant processes in a better way. Accurate runoff estimation is essential for effective management and development of water resources in a catchment. In the present study, we have applied the Soil Conservation Service Curve Number (SCS-CN) method and Hydrologic Engineering Centre's Hydrologic Modelling System (HEC-HMS) for the estimation of runoff of Machhu River Basin, Gujarat, India. The HEC-HMS model uses six techniques to simulate rainfall-runoff modelling. In the present study, we used the Initial and Constant Rate Method as a loss method to estimate the direct runoff component from rainfall events in the HEC-HMS model. The SCS-CN method has been used separately to estimate the runoff of the Machhu River basin. Results of both the methods were compared to evaluate performance of the models. Runoff curve number (CN) is a key factor of the SCS-CN method and it is a function of Land Use/Land Cover (LU/LC), soil type, and antecedent soil moisture. Regression analysis of rainfall and runoff data indicated that R<sup>2</sup> values for SCS-CN method is 0.83 and for HEC-HMS Model is 0.85 suggesting good correlation. Performance of both the methods was evaluated using Root Mean Square Value for observed runoff and estimated runoff as 0.79 for the SCS-CN method and 0.89 for HEC-HMS. RMS values indicated that both the methods have shown good performance in predicting runoff events in the study area based on the rainfall events. Therefore, both these methods can be applied in other catchments also depending on the local geo-environmental and meteorological conditions for accurate prediction of runoff.

**Keywords:** SCS-CN; HEC-HMS; Rainfall; Runoff; GIS; Remote Sensing; Regression Analysis

Paper ID – 205

## Utility of Physical Wave Models for Development of Fishing Harbours – A Case Study for Mopla Bay

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### Abstract

The present study emphasizes on the utility of physical wave model for establishing wave tranquility conditions in fishing harbour at Mopla bay, Kerala on the west coast of India. The full harbour was constructed in 1999 with south breakwater of 360m length and north breakwater of 500m length. Physical wave model studies were conducted at CWPRS for the existing layout of the fishing harbour at Mopla bay, using 3-D physical rigid bed model (Scale G.S. of 1/100) facility equipped with the servo-hydraulic computer based Random Sea Wave Generation (RSWG) system and Data Acquisition System (DAS) with SCADA control. The permissible limit for the wave tranquility was considered as 0.30m for berthing operations at fishing wharfs/ berths located in the harbour basin. The wave tranquility studies were conducted for incident waves from critical SSW direction and South directions. It was observed that mainly diffracted waves from tip of main breakwater approach berthing area of fishing harbour. The adequate wave tranquility was observed at fishing wharfs, berths, turning



circle inside the harbour basin except marginal increase in wave height up to 0.40m at old wharf and hatchery which are located along main breakwater and exposed to the harbour entrance. The loss of operational days at old wharf would be about 3-4 days in monsoon which is insignificant. Physical wave model studies revealed that there is no need of further extension of breakwater/s of fishing harbour since desired tranquility prevails in fishing harbour for its operation throughout the year.

**Keywords:** *Wave tranquility, harbour, breakwater, berth, wharf, diffraction*

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Paper ID – 208

## **Acquisition of depth profile using bathymetry survey near left bank spillway and proposed additional spillway of Hirakud dam, Odisha - A case study**

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### **Abstract**

The Hirakud Dam is constructed across Mahanadi river situated at upstream of Burla town situated in Sambalpur district, Odisha. The project was constructed with the objective to control the floods besides catering the needs of irrigation and hydro power generation. The Chief Engineer, Dam Safety, Secha Sadan Unit-V, Bhubaneswar has requested CWPRS to conduct hydrographic survey for getting the profiles at given Easting and Northing locations for 1.5 km on left bank of Hirakud dam including reservoir portion in front of the proposed additional spillway of the left bank. This cross-section depth profile is needed to construct model at CWPRS for additional spillway studies. The survey was taken up at RL 183.82 m. The bathymetry survey was conducted as per model requirement study area that includes total thirty-nine cross sections with a 50meter grid interval. A motorized fiber boat was used for survey work. The SyQuest Bathy DF-500 single beam dual frequency echo-sounder was used for water depth measurement with an accuracy of 10 mm for 210 KHz frequency. The position of boat in the reservoir was logged with GPS R110 model, Hemisphere make. The GPS unit consisting of receiver antenna for catching satellite signal was used in DGPS mode with beacon correction. By DGPS mode the location of the boat can be obtained with accuracy in sub meter. The depth and position data was stored in a laptop through a 4 port serial RS 232 to USB convertor. The logged data in the laptop was processed using HYPACK navigation software. After editing and filtering the raw data using HYPACK software the analyzed data was plotted for the 39 cross sections consisting of 70 depth profiles using different software such as Q-GIS Surfer, Global Mapper etc. These cross-section depth profiles obtained through bathymetric survey would be utilized in the hydraulic model at CWPRS for carrying out the additional spillway studies of Hirakud dam.

**Key Words:** *Bathymetry, DGPS, Echo-sounder, HYPACK, Surfer.*

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Paper ID – 209

## Physics Based Hydrologic Model for Runoff Prediction in Lower Tapi Basin, India.

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### Abstract

The distributed hydrologic models are useful in prediction of runoff at the outlet of the catchment which makes it an important tool in water resources management and decision making. In the present study, the distributed physics based hydrologic model in MIKE SHE/MIKE 11 has been developed to simulate the overland flow, evapotranspiration (ET), unsaturated flow and channel flow processes in the Lower Tapi Basin (LTB) having area of 3,618 km<sup>2</sup> in India. The distributed model has been developed with cell size of 250 m spatial resolution with consideration of spatially lumped model parameters for vegetation and soil type across the basin. The appropriate value of overland flow resistance parameter (Manning's 'M'), vegetation properties such as leaf area index (LAI) and root depth (RD) for the existing land use land cover class (for Landsat data of 1995) were obtained from the literature. The model was calibrated for the observed streamflow data at Ghala stream gauging station for year 1990-1995 having wide range of climatic (Wet/normal/dry) condition. The performance of the calibrated model also evaluated by using split sampling (independent dataset) technique. The model performance is quantitatively assessed using statistical indicator (RMSE = 312.8 – 341.8 m<sup>3</sup>/s and 119.5 – 130.7 m<sup>3</sup>/s, R<sup>2</sup> = 0.89-0.80 and 0.98-0.97 and NSE = 0.87-0.77 and 0.94-0.84) on daily as well as monthly time scales respectively, during calibration and validation periods. The calibrated model would be useful in the prediction of runoff and water level along the river as well as Surat city located at the tail portion of the Lower Tapi River.

**Keywords:** Distributed physics based hydrologic model, Lower Tapi Basin, MIKE SHE etc.

Paper ID – 210

## Chambal Crocodile Sanctuary: Factors make it a pollution free river stretch

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### Abstract

Chambal River reach of 600 km in the downstream of Kota barrage to its confluence with Yamuna River, is one of the pollution free river reach in India and classified as National Chambal Sanctuary (located at 25<sup>o</sup>23'-26<sup>o</sup>52'N and 76<sup>o</sup>28'-79<sup>o</sup>15'E). It is famous for large number of endangered Gharials, Crocodile and Dolphins. In the present study various factors which make this river pollution free, is discussed in detail. This river reach is a combination of shallow and deep pools. At some of the places river depth is up to 30 m. 40 – 100 m deep river bed from surrounding, untapped tributaries and base flow as the prime contributor are the major reasons behind the unpolluted river reach. Topography of the river and type of the soil on the banks, not support the major cities on its bank and it can be observed that there is no major cities or industries on the banks of this river as like Ganga or Yamuna River. There is number of storage reservoir in the basin which act as a buffer between sewage generated from cities and main Chambal River. They also act as natural sedimentation and oxidation tank for the municipal sewage waste generated from major cities. However, in future there might be increase in pollution level due to various anthropogenic (sand mining, fishing and deforestation) and development activities on the



banks of Chambal River. The results of the present study is useful for the proper planning to control the pollution level in the National Chambal Sanctuary.

**Keywords:** Chambal National Sanctuary, pollution control in river, ecological flow, bio diversity of fresh water

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Paper ID - 212

## **Identification of Hydrologically Efficient Regions in Semi-Arid Yerli Sub-Catchment of Upper Tapi Basin, India.**

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### **Abstract**

The spatial variations in the topography, land use and land cover (LULC), soil and climatic factors lead to spatial variability in the hydrological attributes. The regions of the catchment having high potential for hydroclimatic variables, i.e., rainfall, ground water recharge, surface runoff generation, baseflow, soil water content, water yield etc., and low potential for major loss, i.e., evapotranspiration, are identified as hydrologically efficient regions. In present study, Soil Water Assessment Tool (SWAT) has been used to simulate the hydrological variables for a semi-arid Yerli sub-catchment of Upper Tapi basin in India for period 1990-2013. The SWAT hydrologic model was developed using 30m SRTM DEM, LULC, derived from LISS-III satellite image, Global FAO-soil database, station-based observed weather data. The parametric global sensitivity analysis was carried out using Sequential Uncertainty Fitting (SUFI-2) and it has been observed that the monthly streamflow is more sensitive towards the ground water related processes, channelization of the generated overland flow and land management parameters in the sub-basins. The single site calibration (at Yerli station; period 1990-2005) and multisite validation (at Yerli and Gopal Kheda stations; period 2006-2013) signify 'good' reliability of the model performance, indicated by the statistical parameters, i.e., ( $R^2 > 0.73$ ), ( $NSE > 0.68$ ) and ( $PBIAS < \pm 15\%$ ). The principal component analysis of the space v/s representative/simulated hydrological variables resulted into three statistically significant principal components (PC) with explained variance of more than 85%. Using the combined ranking of the rotated PCs, 20 watersheds (out of 55), having more than 50% share of the study area, have been identified as the hydrologically efficient regions in the sub-catchment. The identified hydrologically efficient and inefficient regions would be useful in employing better water resources and agriculture management practices in the sub-catchment.

**Keywords:** Hydrologic modeling; Principal Component Analysis (PCA); SWAT; SUFI-2; Sensitivity and Uncertainty analysis.

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Paper ID – 220

## MORPHOLOGICAL CHANGES AROUND SOGAL CHANNEL OF DEENDAYAL PORT, GUJARAT IN THE APPROACHES

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### Abstract

All weather Deendyal port trust (DPT) formerly known as Kandla Port Trust, was established in 1949. The hydraulic model studies and analysis of hydrographic surveys are being carried out at CWPRS regularly to optimize the dredging strategy. The existing Sogal channel has been in operation since 1984 starting with a depth of 3.7m and is divided in different segments in the form of Buoy number 12 -13 to Buoy number 4. The hydrographic surveys of the 350m wide approach channel having side slope of 1:5 consisting of a bend portion starting from Buoy number 12-13 to buoy number 8A-9A for different years (from the period 1984 to till date) have been analysed rigorously to assess the morphological changes in the vicinity of Sogal channel. The depth of the channel has been progressively increased from 3.7 m to about 9.0 m at present, with minimum quantity of maintenance dredging as a result of recommendations from hydraulic model studies (both physical and mathematical models) at CWPRS. The critical areas for dredging have been identified and zone wise dredging strategy has been suggested. Further, an empirical equation to predict the morphological changes in the approach channel at Kandla has been formulated on the basis of the prototype data base available at CWPRS. This empirical equation is valid for site specific for the soil classification in the channel with mean grain size of about 0.08mm.

**Keywords:** hydrographic survey, model, morphology, prototype, Sogal channel.

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Paper ID – 223

## Physico Chemical analysis of the industrial effluent and sewage their effect on the water quality and soil of getting river harmu in Ranchi.

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### Abstract

Industrial Effluents entering the water bodies is one of major sources of environmental toxicity. It not only affects the water quality but also has deleterious impact on the soil and aquatic ecosystems. Soil is the most favorable habitat for a wide range of microorganisms that includes bacteria, fungi, algae, viruses and protozoa. Industries keep on releasing effluents, which is quite toxic whether its fertilizer industries, or chemical treatment given to the fields also cause problems for the survival of the water quality and soil. Industrial and commercial effluents are characterized by their abnormal turbidity, conductivity, chemical oxygen demand (COD), total suspended solids (TSS), biological oxygen demand (BOD), and total hardness. Industrial wastes containing high concentration of microbial nutrients would obviously promote an after-growth of significantly high coliform types and other microbial forms. In the present study we have analyzed the effluents of fertilizer industries and sewage effluents getting river harmu and their deleterious effects on the water quality and soil. Analysis of the industries effluent shows that the ph. (7.1 – 9.1); TSS (115.5 – 203.83); TDS (2260 – 3080), BOD (80 – 110) and COD is (260 – 350) whereas in the sewage effluents ph. (8.1 – 9.1); TSS (301 - 494); TDS (2150 - 2500), BOD (60 – 100) and COD is (255 – 340). The values exceed the NEQS and BIS values. Hence, the values pH, TSS, TDS, BOD and COD are above the permissible limits. Organic pollution is always evident and the pollution



is made worse by land-based sources such as the occasional discharge of raw sewage through storm water outlets, and industrial effluents from refineries, oil terminals. Waste effluents rich in decomposable organic matter, is the primary cause of organic pollution.

**Keywords:** Harmu River; Industrial Effluent; sewage; BOD; COD; TDS; TSS

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Paper ID – 224

## Activation of central channel in river Kosi, Bihar

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### Abstract

Kosi river carries large amount of sediments which get deposited in the internal delta portion of Nepal and Bihar resulting in formation of braided river. The river keeps changing its course inside the restricted manmade embankments. It has shown greater affinity to flow along the line connecting the noses of spurs provided to push the flow away from the embankments. As the river is dynamic in nature, it poses frequent migration to either bank during passage of each flood. The migration of channels along the existing spurs and embankments causes concern to the engineers and danger of breaching of the embankments. Since, the embankments are composed of only consolidated soil without protection to its slope and other protective measures such as geofabric filter, launching apron, etc., at most of the reaches, there is a possibility of erosion of embankment, if left without managing such flow conditions. However, due to the presence of intermittent spurs, the attack over the embankment is restricted. The spurs being almost perpendicular to the embankments are helpful in managing flow conditions that are parallel to the embankment. But due to the formation of braded channels, there are formations of channels that tend to flow at critical angles towards the embankment bypassing the effect of spurs. During the floods of 2016, a channel developed which was directed towards the eastern Kosi embankment just upstream of Prakashpur in between spur at 27.88 km to 24.78 km upstream of Kosi barrage in Nepal portion. This caused major damage in the form of erosion to the nose and shanks of the nearby spurs. To train the river in order to minimize the attack on the said reach, studies were conducted in the existing mobile bed physical model at CWPRS to assess the efficacy and sustainability of the proposed channel in front of spurs at 27.88 km to 24.78 km, upstream of Kosi barrage. The project authorities proposed a pilot channel adjacent to the said reach over the shoal for activation thereby reducing the pressure of flow in the channel along the eastern embankment (left bank). The model studies conducted indicated that proposed pilot channel was not able to absorb large quantity of discharge and was unable to reduce flow intensity in the channel adjacent to the eastern embankment and also will get silted up over the period. Alternatively, a channel on the right side of the said shoal was able to absorb large quantity of flow given some minor modifications. Hence, based on the studies, it was recommended to activate the existing channel on right side of the shoal opposite to the spurs from 27.88 to 25.25 km including streamlining in plan near the mouth, dredging/de-silting at the upstream junction and deepening of channel by about a meter over a length extending about a kilometer along the right-side channel. In addition, the activation of right-side channel was found to be efficient and sustainable if resistance to flow in the form of porcupine screens were provided in the parallel channel along the eastern embankment in addition to the above modifications. Based on the studies conducted and recommendations made by CWPRS, Pune, the project authorities carried out the river training works. It was seen in the subsequent years that after passage of each flood since 2017, the right channel got activated appreciably and is still trending to activate further. This resulted in gradual reduction of pressure along the eastern embankment near spur at 27.88 km to 24.78 km, upstream of Kosi barrage. The trend was also verified using the satellite imageries.

**Keywords:** Kosi river, Eastern Embankment, pilot channel, RCC porcupine, spurs, activation of channel.

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## SHORELINE CHANGE ANALYSIS BEHIND SOUTH BREAKWATER OF PARADIP PORT BY DSAS TECHNIQUE

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### Abstract

Coastal phenomena are dynamic in nature by various coastal and metrological parameters. Shoreline-change data is one of the key parameters for understanding coastal erosion (landward retreat) and deposition (advance and growth through accretion) along with coastal morpho-dynamics. Satellite images are found to be low-cost alternative for extraction of shoreline and as an addition to traditional methods. The Digital Shoreline Analysis System (DSAS) as a software extension within the Environmental System Research Institute (ESRI) ArcGIS© has been used by many scientists in measuring, quantifying, calculating and monitoring rate-of-change of shoreline statistics from multiple historic shoreline positions and sources. In this study, the shoreline changes for selected stretches behind the South breakwater of Pradip port were analyzed. Satellite-derived shorelines and corresponding shoreline-change rates have been estimated and evaluated. The Land sat archive data for different years were downloaded from the website - <http://earthexplorer.usgs.gov/> The important factors considered for finalizing the satellite images were cloud cover, similar tide conditions, similar season data, uniform projection system, etc. Now UTM WGS 84, Zone 45N projection system was used for analysis. The shoreline features were identified using tonal differences between land and sea. A band ratio technique was applied to differentiate land and water pixels. Further vectorization technique was applied to get shoreline features in Arc-GIS environment. To further refine results visual interpretation was carried out for editing shoreline features to enhance accuracy. Finally, shorelines were obtained for the years 1992, 1997, 2003, 2008, 2013 and 2018. Shoreline-change rates has been estimated using time series of satellite-derived shorelines. The shoreline change statistics were derived based on Net Shoreline Movement (NSM) technique. The net shoreline movement reports a distance, not a rate. The NSM is associated with the dates of only two shorelines. It reports the distance between the oldest and youngest shorelines for each transect. This represents the total distance between the oldest and youngest shorelines. End Point Rate (EPR) is another important parameter, which indicates the rate of movement of shoreline and erosion/accretion. Through this study the net shoreline movement behind the south breakwater of Pradip Port is calculated very accurately and comparable with the filed data. From EPR the rate of movement of shoreline is computed.

**Key words:** Landsat images, GIS, Historical Trend Analysis, DSAS, Shoreline Changes, transects, PR.

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Paper ID – 244

## Development of a distributed physics hydrological model for prediction of inflows into Hathnur Reservoir from Main Tapi River in Upper Tapi basin, India

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### Abstract

The present study aimed at evaluating the performance of a deterministic physics-based distributed model, MIKE SHE coupled with MIKE 11 to have a good understanding of the occurrences of the overland flow and channel flow in the Burhanpur sub-catchment of Upper Tapi basin and predict inflows into the Hathnur reservoir. The catchment covers an area of 10,340 km<sup>2</sup> and has mountainous and steep topography with the deciduous forest as the dominant land cover class. A grid size of 500m x 500m has been used in the foregoing modeling. The distributed nature of the topography, land use class of the catchment, and meteorological data are given as inputs using the Shuttle Radar Topographic Mission (SRTM) Digital elevation model (DEM) of 30m resolution, IRS P6 LISS III, and station-based rainfall and potential evapotranspiration (PET) respectively. The integrated model has been calibrated against daily observations of stream flows at Burhanpur stream gauging station for four years from 1993-1996. The auto-calibration is performed using the AUTOCAL tool of DHI for minimizing the overall root mean square error of daily discharges. The calibrated parameters are validated using independent data of the years 1997-2000. The model performance indicators demonstrated that the model predicts satisfactorily stream flows at daily and monthly time scales (NSE=0.60-0.93, r=0.80-0.95) for calibration and validation periods for the Burhanpur sub-catchment. The model performance analysis indicates the usefulness of the model in predicting the inflows into the Hathnur reservoir.

**Keywords:** Hydrological model, Distributed physics-based, Burhanpur sub-catchment, MIKE SHE/MIKE11model

Paper ID – 258

## A comparison between flood models developed using topographical details from field survey and SRTM DEM using MIKE HYDRO River

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### Abstract

The quality of terrain data and the cross-sectional details of the river are very important factors influencing the modelling of flood. The main objective of the study is to compare the flood model developed using cross sections measured in the field and generated from the freely downloadable SRTM DEM using MIKE HYDRO River model and to analyse its effect. The study area considered for the analysis is Pamba River in Kerala. In this study, we utilize the time series of daily discharge and water level of different gauging station of Centre Water Commission at Kallooppa, Malakkara, Thumpamon and water level data of Thottappalli spillway, measured cross sections in the field and SRTM DEM were used to generate the flood model for the for the period June to August 2010. The model is developed for three scenarios i) with surveyed cross sections, ii) cross section generated from DEM and iii) corrected DEM cross sections. The study shows good correlation between the outputs of the flood model developed using the surveyed cross section and the observed discharge. When the SRTM DEM is corrected with the observed elevation from MSL the model developed gives more comparable



values to the model developed using surveyed cross sections than the uncorrected DEM. The correlation coefficient value ranges from 0.91 to 0.96 in all three cases. The model developed using DEM cross sections can be used for the simulation of one-dimensional model when the measured cross sections were unavailable and it also make the study more economical.

**Keywords:** SRTM DEM; Pamba; MIKE HYDRO River; Flood modelling

Paper ID – 269

## **A Rainfall- Runoff Simulation Model for estimation of Floods for Purna River Basin Part of Upper Tapi Basin**

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### **Abstract**

Floods are the most widespread climate-related hazards in the world and affect more people around the world. Rainfall and subsequent runoff produced are the most important processes of hydrology. The aim of this research is to develop a rainfall runoff model for the Purna River basin (Upper Tapi). The objective of this study is to determine the runoff of Purna basin using Hydrologic Modelling System (HEC-HMS). Purna is one of important tributary of Tapi River. For the prediction of peak flow based upon the available historical precipitation data, land use condition, soil type and suitable routing method is selected. Digital elevation model was used to delineate the watershed. Using precipitation data hydrological model is developed in HEC-HMS. The main aim of this study is to develop modelling system for flood prediction for Purna basin. After optimization of the model result shows relatively close agreement between the simulated and observed flow values during the calibration period ( $R^2 = 0.95$ ) and root mean square and mean absolute error are also low. So, this model helps to visualize the response of water systems due to changes in the land-use and meteorological events.

**Keywords:** Rainfall-Runoff, Purna river, Flood estimation, ARC-GIS, HEC-HMS

Paper ID – 270

## **Hydrodynamic challenges and role of physical model in evolving layout of boat landing facility at confluence of Elephanta deep and Nhava creek**

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### **Abstract**

Jawaharlal Nehru (JN) Port is developing a mega container terminal in Thane creek and as a social responsibility, development of boat landing jetty at the confluence of Elephanta deep/Nhava creek for the transport of passengers from Nhava Island to Mumbai is under consideration. JN port area is free from wave disturbance being well inside from the entrance to Arabian Sea. However, presence of macro type of tides (range of 5 m), siltation; govern the hydraulic design criteria for waterfront facilities. The location of boat landing jetty is in hydrodynamically complex region wherein steep bathymetry varying from +1 m CD at entrance of Nhava Creek to -15 m CD at recently deepened navigational channel of JN Port exists. It causes change in the direction of flow, formation of dynamic eddies and flooding/drying of area in-front of jetty. As such to finalize the safe alignment of boat landing jetty, studies were carried out in a distorted physical model (Scale 1:400(H) & 1:80(V)). The flow patterns observed during tidal phase reveal that, current strengths are strong (1.27 m/sec-0.97



m/s during spring/neap tide), while its direction varies between 214<sup>0</sup>-224<sup>0</sup> N and also there are formation of dynamic eddies during few hours of ebb tide. Thus, original jetty alignment at 26<sup>0</sup> N needs modification to 36<sup>0</sup> N and reclamation on leeside of jetty further improves the flow field at jetty. Dredging up to 1.2 m depth below CD over an area of 2.5 ha, in front of jetty also improves the operability at the jetty.

**Keywords:** Creek; Eddy; Hydrodynamics; Jetty; Tides

Paper ID – 278

## Estimation of rainfall erosivity factor of Guwahati with high temporal resolution rainfall data

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### Abstract

Due to extensive deforestation happening in hilly areas of Guwahati, the city has been facing soil erosion problem. Soil erosion again ignites the problem of occurrence of flash floods in the city as the eroded soil often deposited in the drains and reduce the water carrying capacity. Hence, holistic studies and various erosion control measures are the need of the hour. The first step in both the cases is the estimation of soil-loss happened due to soil erosion. Revised Universal Soil Loss Equation (RUSLE) is a famous method for estimating soil-loss caused by rill or inter-rill erosion. Rainfall erosivity factor (R) is one of the most important factors of RUSLE. Very high temporal resolution rainfall data for a long period is required to estimate the R factor as per RUSLE handbook. Moreover, the calculation method is also very tedious. There are lots of simple empirical methods available to calculate the R factor by using readily available rainfall data. However, the accuracy of those methods differs from place to place and may yield incorrect results of R factor and soil-loss. So, the present study is conducted to evaluate the R factor of Guwahati by using 19 years' half-hourly rainfall data as per RUSLE handbook. The calculated R factor of the city is 7623 MJ. mm/ha.hr. yr. In many previous studies, an R factor value calculated in the year 2004 by 1-year hourly data has been using for calculating the soil loss in the city. This newly calculated R factor, with a longer period and higher temporal resolution rainfall data, will enhance the accuracy of soil-loss estimation and other related studies.

**Keywords:** Soil erosion; RUSLE; Rainfall erosivity factor

Paper ID – 281

## Hydrodynamic Modelling of Upper Tapi River, India

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### Abstract

The prediction of River stage and discharge is required for effective flood management by adopting some structural and non-structural measures. The present study addresses the development of one-dimensional Hydrodynamic model using MIKE 11 software to simulate hydraulic characteristics of flow for Upper Tapi



River between Deditalai to Hathnur gauging station having reach length of 120 km. The calibration of the unsteady simulation model was performed for the flood event of the year 1994 with the due consideration of upstream (flood hydrograph) and downstream (water levels) boundary conditions to estimate the optimum value of the roughness coefficient. The comparison between the time series of simulated and observed water levels at the intermediate station, i.e., Burhanpur, was conducted to estimate the optimum value of the Manning's coefficient. The performance of the aforesaid developed model was also assessed using the standard performance indices such as Root Mean Square Error (RMSE) and Coefficient of Determination ( $R^2$ ). The calibrated model was also validated using the independent flood events of the year 1998 and 2015. In addition, the rating curve was established using the simulated results of the developed model, which can be used in future to predict the discharge at the section based on river stage. The energy slope obtained from the MIKE 11 result file was used to estimate the stream power and the energy lost during the flood. The stream power obtained for the flood year 1994 was enough to move the small size boulders along the Upper Tapi River.

**Keywords:** Hydrodynamic modelling, MIKE 11, Upper Tapi River, Manning's roughness coefficient, Rating curve, Stream power.

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Paper ID – 294

### Land use/land cover change impact assessment on stream flow over Vamanapuram river basin

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#### Abstract

Land-use change has a significant impact on major components of the hydrologic cycle such as precipitation, evapotranspiration, infiltration and runoff, which may lead to disasters like extreme flood and drought. In this study, we analyzed the streamflow changes over the decades due to change in land use for a particular climate. Rainfall-Runoff modelling is a mathematical representation describing the relation between rainfall and runoff to the catchment area, which is influenced by the hydrologic processes, topography and soil types. SWAT (Soil Water Assessment Tool) is a widely used rainfall-runoff model to understand the hydrological behaviour of the watershed. SWAT model has been developed to simulate rainfall-runoff for the Vamanapuram river basin. The basin was divided into 12 sub-basins using an automated delineation routine with Cartosat DEM as input. The model was run with a fixed climate data of 35 years (1981-2015) including two years of warm-up period (1979-1980). SWAT-CUP was used to calibrate and validate the model using the 1990 LU/LC. The SWAT model has been calibrated using monthly data of 20 years for two different land uses (1990, 2000) with observations from the Ayilam gauging station. The model with 1990 land use is calibrated for ten years (1986-1995) and validated for four years (1996-1999). Similarly, the model developed using the land use map of the year 2000 is calibrated for another ten years (2000-2009) and validated for three years (2010-2012). The models yielded satisfactory and reliable results with coefficient of determination and Nash-Sutcliffe Efficiency 0.73&0.72, 0.81 & 0.8 for calibration and 0.71 & 0.69, 0.73 & 0.76, respectively for validation of two models. The two models show a similar set of fitted parameters. The model simulated with different years of land use map prepared using Landsat imageries, with a fixed climate and analysed the average annual change in stream flow over the decades. The area of land use classes like Built-up, plantation increased, whereas forest and agriculture decreased. There is a reasonable increase in streamflow observed between the years which was due to deforestation and urban growth.

**Keywords:** SWAT; SWAT\_CUP; land use/landcover change, hydrological modelling

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Paper ID – 302

## **SURFACE WATER QUALITY ASSESSMENT OF KENO REACH OF KLAMATH RIVER USING PCA-ENTROPY MODEL**

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### **Abstract**

Surface water quality has a vital role when defining the sustainability of the ecological environment and public health as the quality of rivers and lakes are central to human and economic development. Water quality has become a global concern due to over increasing population and development activities which overexploit and pollutes the water resources available to us. Assessment of water quality is important for knowing the suitability of surface water for various purposes. This study proposes a new methodology for assessing surface water quality using a combination of Principal Component Analysis (PCA) and Entropy weighing method. Eight sampling stations were monitored along Keno reach of Klamath River, Oregon and California for the evaluation of surface water quality. PCA was carried out for each station separately for computing synthesized factor equations. An evaluation matrix was developed using the synthesized factor equations of all stations and entropy weighing method was used to compute the objective weights of the water quality parameters. The synthetic scores of the sampling stations were estimated using the evaluation matrix generated from PCA and parameter weights from Entropy method. Combined PCA – Entropy model provides fast, time saving and reliable results and it takes care of the uncertainty as well unlike conventional PCA model. The overall river water quality, parameters order of importance and station rank can be computed using this combination model.

**Keywords:** Surface water; assessment; PCA; Entropy; factor; evaluation matrix; synthetic scores

Paper ID – 306

## **Relative performance of continuous and event-based hydrological models for Dharoi catchment of Sabarmati basin in India.**

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### **Abstract**

In present work, event-based and continuous rainfall-runoff models are developed for Sabarmati river basin at Dharoi catchment (5285.9 km<sup>2</sup>) using HEC-HMS 4.3 with gridded rainfall input at 0.25° × 0.25° spatial resolution. The SRTM DEM (30 m) was used to delineate the sub-basin and physical properties were estimated using HEC-GeoHMS. The developed models utilize Soil Conservation Service Curve Number (SCS CN) and Soil Moisture Accounting (SMA) loss method for the computation of runoff volume, SCS unit hydrograph for the computation of peak runoff rate and Muskingum routing method for the flow routing. The event-based hydrologic model using SCS CN method gave satisfactory results, and it is found that curve number, Initial abstraction and Muskingum “K” are the most sensitive parameters of the study area. Further, it is observed that curve number has been found to be higher and Muskingum “K” is lower for wet year as compared to normal and dry years for event-based hydrologic model. The results indicated that NSE values for Dharoi catchment was in the satisfactory range of 0.58-0.72 and 0.65-0.74 during calibration and validation periods respectively. The coefficient of determination (R<sup>2</sup>) and percent error in volume (PEV) of the predicted model were found to be satisfactory. The calibration results of continuous modelling using SMA loss method shows that the parameters related to soil and groundwater are the most sensitive parameter, whereas, the parameters related to baseflow



(i.e., GW2) as well as lag time are found to be the least sensitive. The continuous model for Dharoi catchment using SMA was calibrated for years 2009 and 2011 and validated for year 2013. The results indicated that NSE values for Dharoi catchment is in the satisfactory range of 0.65-0.72 and 0.71 during calibration and validation periods respectively. The coefficient of determination ( $R^2$ ) and percent error in volume (PEV) of the predicted model were found to be good. The results have been found to be satisfactory and can be improved by considering the data of larger number of years for calibration period.

**Keywords:** Rainfall, SCS-Curve Number, Runoff, Sabarmati basin.

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Paper ID – 312

## Optimization of common energy dissipator for the two-tier spillway – A case study

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### Abstract

Siang Lower H. E. Project is a run-of-the-river scheme located on Siang River in East Siang district of Arunachal Pradesh. It is proposed to construct 86 m high and 709.48 m long concrete dam. The spillway has to perform dual functions of disposing the flood as well as flushing the sediments. Due to the geological constraints, the power house has to be accommodated in the dam body. This made the space for the spillway to pass the design flood restricted. Hence, the spillway arrangement envisaged was unique, consists of two-tier spillway comprising overflow ogee spillway on the top tier and sluice spillway in bottom tier. A common energy dissipator in the form of stilling basin was provided for both overflow and sluice spillways due to corresponding high tail water. The stilling basin provided was acting as a typical hydraulic jump basin when only sluice spillway is operated; but, it will act as plunge pool for the overflow spillway operation. For both spillways operating the design was hydraulically complex as there was interaction of flow at the junction of exit of the lower and upper spillways. The design becomes more complicated as the power house is provided adjacent to the spillway and interaction between the flow in the stilling basin and tail race channel is envisaged. The design of these structures cannot be standardized and mainly governed by site specific conditions. Physical model investigations are required for optimizing the hydraulic behavior of the energy dissipation arrangement. This paper describes the hydraulic model studies conducted at CWPRS, Pune, which played an important role in enhancing the overall performance of spillway and energy dissipator by incorporating various modifications to the sluice roof & bottom profile, overflow spillway profile, length & elevation of the stilling basin, end sill etc. The details of model studies conducted on 1:55 scale 2-D sectional and 1:100 scale 3-D comprehensive models for improving the overall performance of common energy dissipator is described in the paper.

**Keywords:** Two tier spillway; Overflow spillway; Sluice Spillway; Ski-jump bucket; Stilling Basin

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Paper ID – 330

## **Spatial variation in water quality of Mula-Mutha River flowing through Pune city and suburbs, Maharashtra**

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### **Abstract**

In order to carry out river rejuvenation, existing water quality and trends in the water quality of that river is essential. To study the present water quality and changes in water quality due to rapid growth in population, urbanization and industrialization, 127 km stretch of Mula-Mutha river flowing through Pune city and suburbs starting from Khadakwasla dam (S1) up to Daund (S7) located in upper Bhima Basin was selected. This work was carried out as a Purpose Driven Study (PDS) under National Hydrology Project (NHP). This study will help to suggest improvement measures for restoration of water quality. During February 2020, a field visit was carried out to collect in-situ data, water and biological samples from seven locations. Laboratory analysis was carried out for Physico-chemical and biological parameters. Based on the results obtained during the entire study period, spatially Mula-Mutha River can be divided into 3 zones. The middle portion of the river of the length 15 km was observed to be heavily polluted having dissolved oxygen levels dipped to 0 mg/l or very close to 0 in three locations and causing damage to river ecology and self-purification of the river. Possible reasons for spatial variation in Mula-Mutha river water quality and its implication on river rejuvenation are discussed in detail in the paper. The water quality data obtained through field visits and spatial variations observed through data analysis are used in developing a water quality model for the Mula-Mutha River.

**Keywords:** River; water quality; river rejuvenation; mula-mutha River

Paper ID – 350

## **Development of Hydrological Model (Mike 11 Nam) For Simulation of Stream Flows at Burhanpur Station in Upper Tapi Basin, India**

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### **Abstract**

Water availability is a major concern for a proper water resource planning. There have been remarkable advancements in numerical modelling of hydrological processes at catchment scale with the use of remote sensing, Geographic Information system (GIS) tools etc. In the present study, the outflows from Burhanpur sub-catchment in Upper Tapi Basin are simulated by developing a lumped conceptual hydrological model using MIKE 11 NAM. The hydrologic model was calibrated based on minimization of percentage of water balance (% WBL) and root mean square error (RMSE) using the observed streamflow data of Burhanpur stream gauging station during the years 1993-1996. The multi-objective function here has been calibrated using global optimization algorithm, i.e., Shuffle Complex Evolution algorithm. The calibrated value of maximum surface storage and the coefficient of overland flow was found to be high due to large forest cover and steep slope of the catchment respectively. The model performance was evaluated using statistical performance indices. The



simulated results show that the NAM model can simulate hydrographs satisfactorily with NSE (0.854-0.797), RMSE (295.626-383.611) m<sup>3</sup>/s and WBL (1.0-1.2) % at daily time scale. Thus, the NAM model can be useful for the prediction of outflows at Burhanpur sub-catchment.

**Keywords:** Hydrological Model; Water balance; Shuffle Complex Evolution algorithm; Maximum surface storage; Coefficient of overland flow; MIKE 11 NAM

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Paper ID – 353

## Prediction of discharge in non-prismatic compound channel using Extended ISM

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### Abstract

In a compound channel, vertical apparent shear exists on the interface between the upper main channel and the floodplain, which generally accelerates the flow on the floodplain and resists the flow in the upper main channel. In addition, a horizontal apparent shear stress also occurs on the interface between the upper and lower main channels, which generally accelerates the flow in the lower one and resists the flow in the upper one. Therefore, it is essential to consider the exchanges of momentum at both vertical and horizontal shear layer regions. This concept is incorporated in extended independent subsection method (Extended ISM). In this method calibrating factor is necessary for mass exchange and turbulent exchange. In this research, an equation has been developed to calculate the calibrating factor. For this different experimental data has been collected on converging and diverging compound channels. To check the efficiency of the Extended ISM in predicting discharge in non-prismatic compound channels, comparison has been made with classical ISM. The statistical error analysis has also been performed to check the strength of the model in predicting accurate discharge.

**Keywords:** Extended ISM; converging; diverging compound channel; turbulent exchange

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Paper ID – 379

## Simulation of Rainfall-Runoff Process using HEC-HMS

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### Abstract

Water is the prime natural resource and the main element in the socio-economic development of a society. There is a huge demand for studying the runoff yield and flow dynamics of surface and sub-surface. Runoff estimation is a challenging part for hydrologists due to the involvement of various hydro-meteorological and geographical factors. Rainfall is the key component of the hydrologic cycle and the principal source of runoff. The purpose of this study was to simulate the rainfall-runoff process using the HEC-HMS model. The study was carried out in Eastern India's Brahmani River Basin at Gomlai catchment. Catchment delineation was processed for the extraction of the basin parameters using Arc-GIS software. HEC-Geo HMS was used which is a geospatial hydrologic extension tool in Arc-GIS for transferring basin real-time geo-hydro-meteorological characteristics



to the HEC-HMS. Herein, the SCS-CN method for loss, SCS unit hydrograph technique for transform, Muskingum method for routing, and recession curve method for baseflow estimation was used. The calibration was carried out using a time-series of flow for the year 1982. The performance evaluation measures such as NSE, PEV, and  $r^2$  were found to be 65%, 6.04%, and 0.67 respectively during calibration of Muskingum parameters. Similarly, validation of Muskingum parameters was carried out using different annual and continuous time-series of flow data. During validation of annual time-series data the NSE, PEV, and  $r^2$  values were found to be 70.88%, 7.25%, 0.7123 respectively. Similarly, during validation of continuous time-series data for the year 1990-1995, the NSE, PEV, and  $r^2$  values were found to be 67.11%, 9.34%, 0.6738, respectively. Hence, in this study, it is concluded that the HEC-HMS can be efficiently applied to estimate runoff yield using real-time geo-hydro-meteorological data.

**Keywords:** Rainfall-Runoff, HEC-HMS, HEC-GEOHMS, Brahmani River

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Paper ID – 401

## Comparative Evaluation of SRTM and MERIT DEMs in Simulating Streamflow Dynamics in a Complex Deltaic River Basin

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### Abstract

Hydrodynamic modelling of the complex river systems plays an important role for operational flood control that involves accurate estimation of streamflow and river stage. Since the river stage is a local variable, it is very much sensitive to the accuracy level of the Digital Elevation Model (DEM)-extracted river cross sections. Among the freely-available DEMs, 1-arc second SRTM and 3-arc second MERIT DEMs are very much popular among the researchers worldwide. In this study, the sensitiveness of the river cross sections extracted from these two DEMs was evaluated by using the dynamic wave routing option of the MIKE11-HD model in simulating the river stage and discharge along the complex river network of the deltaic 'Lower Mahanadi Basin (LMB)' (4434 km<sup>2</sup>), which is one of the severely flood affected areas in eastern India with flat terrain. The LMB constitutes a network of 16 river distributaries originating from the main Mahanadi River and finally draining into the Bay of Bengal and Chilika Lake. Moreover, there is a dense canal network with three main canals originating from the gated structures located on the main Mahanadi River, conveying water to eight branch canals and several major and minor distributaries. Due to this complexity, it is challenging to simulate river stage and streamflow along the stream network downstream with the freely available DEMs. The observed daily streamflow and river stage available at two gauging stations for the period of 2004-2005 and 2006 were used for model calibration and validation, respectively. The results reveal that with the SRTM DEM, MIKE11-HD could simulate the streamflow reasonably well with the Nash Sutcliffe Efficiency (NSE) of 0.41-0.61 both during calibration and validation; whereas for the corresponding NSE for simulating the river stage was 0.22-0.38. Conversely, with the MERIT DEM, there were improved NSE estimates of 0.45-0.63 and 0.27-0.41 for simulating the discharge and stage, respectively. Conclusively, the freely available DEMs are capable of simulating the river discharge reasonably well. Furthermore, a careful consideration of uncertainty involved in the extracted river cross sections along with the inclusion of lateral flow at different river reaches would definitely improve the model efficiency.

**Keywords:** Streamflow routing, SRTM DEM, MERIT DEM, MIKE11-HD, Flood forecasting

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## Energy Dissipation Modeling in Highly Braided Brahmaputra River

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### Abstract

The hydrodynamic river models are widely used for flood forecasting, sediment transport, water quality, and channel navigation studies. However, such river models are seldom applied to the process-based understanding of energy dissipation in large river systems. The energy dissipation becomes more complex in highly braided rivers due to spatio-temporal heterogeneity in flow-morpho dynamics-vegetation interactions. The Brahmaputra, one of the highly braided river systems globally, is characterized by large seasonal variability in flow, sediment transport, and channel configuration. Moreover, this river basin is poorly gauged, which offers a challenging task for flow-dynamics simulation and hydro-geomorphological predictions. Hence, in this study, HEC-RAS hydrodynamic model was simulated to understand the energy dissipation process for highly braided Brahmaputra river. The selected study reach near Guwahati is 200 km in length, which is morphologically active in terms of sand-bar adjustments, thalweg shifting, large eddy formation, the emergence of heterogeneous vegetations, and extensive bank erosion. Hydrological data (stage and discharge), bathymetry (surveyed coupled with google earth), and geospatial (optical images, DEM and altimetry) have been used to set up the one-dimensional hydrodynamic model. Preliminary results establish that energy dissipation is significantly high ( $> 15$  MW/km) close to the nodal section producing large-scale morphological variability. Bed changes at the nodal sections have been observed close to 2 m, and the value is more than 2 m for the discharge 70000 cumecs. A periodicity in channel aggradation and degradation was also observed upstream and downstream of the nodal section. Finally, a less amount of sediment concentration (500 mg/L) was observed near the Guwahati nodal section. Further analysis will be carried out to integrate sediment transport and entropy theory to understand spatio-temporal variability of energy dissipation at different hierarchical geomorphic units.

**Keywords:** Hydrodynamic Model; Braided River; HAC-RAS; Energy Dissipation.

## Simulation of Water Level Oscillations in Orifice Type Surge Tank under Sudden Changes in Turbine Inlet Discharge

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### Abstract

Hydropower plants provide clean and renewable energy to cater the power demand of the nations at very affordable unit cost. High head hydropower projects need construction of long and large water conveyance system in form of tunnels and penstocks. The safety of such components needs to be assured under critical operating conditions of the power plants. The high-pressure surge in the headrace tunnels due to transient flow occurred due to sudden load rejection may cause the severe damage to tunnels and that can be prevented by providing surge tank at the end of tunnel. Due to unsteady flow conditions, the prediction of water level oscillations in the surge tank need solution of differential equations governing flow conditions. In this study the Runge-Kutta four step method is applied to develop the model for simulation of orifice type surge tank. The model is applied to the surge tank that resembles the proposed surge tank of Tehri Pump Storage Project. The model is applied to investigate the effect of variations in orifice discharge coefficients and orifice diameter. The maximum upsurge



and down-surge are computed under various turbine discharge variations. The effect of time of closure on maximum upsurge is also observed. It is concluded that in absence of precise analytical solution, the numerical model provides very useful information to finalize the dimensions of the orifice type surge tank.

**Keywords:** Surge tank, Unsteady flow, Hydropower

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Paper ID – 433

## Simulation of Ajwa Reservoir using HEC-ResSim

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### Abstract

Water is necessary for sustainable human development as well as for the healthy functioning of the planet's ecosystem. To increase the safe yield of non-perennial rivers to supply water for increasing population, dams and reservoirs are essential. For existing reservoirs, the operation of the structures is becoming more and more challenging under stochastic behavior of rainfall and intense rain events. The augmentation of small reservoir supply needs additional inflows from nearby large canal systems and adjoining reservoir. The difficulty of the small storage causes additional threat under flood event due to sudden release from reservoir to the downstream area. To help decision making process for operating reservoir under water conservation and flood routing scenarios, computer models are very useful. In this study, a model is developed using HEC-ResSim for operation of Ajawa reservoir near Vadodara, India. The reservoir is more than 100 years old providing raw water to Nimeta treatment Plant for drinking water requirement of Vadodara City. To augment the inflow into reservoir, it is connected with nearby Pratappura reservoir through feeder canal. Sardar Sarovar Canal water is also available to reservoir under deficit condition. HEC-ResSim is used to construct the Ajwa reservoir simulation model with inflow and outflow facilities. The model is used to investigate additional requirement from Sardar Sarovar Canals under normal monsoon. The HEC-ResSim is found very useful tool for testing various operating scenarios.

**Keywords:** HEC-ResSim, Reservoir Operation, Ajwa Reservoir, Reservoir routing

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Paper ID – 441

## Computation of Hydro-Electric Power Generation on Canal Falls of Vadodara Branch Canal

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### Abstract

Hydropower is a renewable, non-polluting and environmentally benign source of energy. The current study represents the first step in a comprehensive field study to quantify the amount of power generation through the small hydro power project (SHP) and inspire to construct such structure with irrigation infrastructure in India. This paper is present in-depth scenario on proposed SHP going to begin on Vadodara Branch Canal (VBC) of Narmada Canal system. VBC is off take at 81.804 km of Narmada Main Canal (NMC) having total length of 115.05 km. Sardar Sarovar Narmada Nigam Limited (SSNNL) identified six fall sites on Vadodara Branch Canal (VBC) at chainage; 6720m, 11080m, 14580m, 21000m, 22500/22800m and 24290 m. The project envisages setting up SHP at above fall sites to harness available hydro energy. Also this study includes evaluation of design capacity for power generation for various canal falls. The SHPs will generate power from the irrigation releases through the VBC by utilizing the water heads available at the fall locations between the upstream water level and downstream water level of the fall. Irrigation being the main purpose of the VBC, some of the SHPs are planned to utilize the releases as available in the canal in a non-consumptive way. The work presented here describes a method of analyses and assess the potential of hydro power generation through various canal falls situated along the VBC to support an estimation of availability of total power potential on given fall site for small hydro power project.

**Key Words:** Hydropower, Small Hydropower Project, Renewable Energy, Sustainable Development, Irrigation Canals, Canal Falls

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Paper ID – 445

## A GIS-based Seasonal Water Quality Profiling of Parbati River, Himachal Pradesh, India

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### Abstract

Various literature surveys reveal that RS and GIS have not been used to assess the quality of rivers/streams in the higher altitude of North-western Indian Himalayan Region (IHR) and to prepare water quality maps that could be helpful for decision-makers and the general public to understand the present environmental scenario in the higher altitudes of IHR. The current paper presents a case study on the water quality analysis carried out at the Parbati river valley of Kullu district, Himachal Pradesh. River Parbati is a tributary of River Beas which rises from the Mantalai Glacier Lake to the Pin Parbati Pass and flows from north-northwest to west-southwest direction. The main objective of the present study is to develop a GIS based map of the Parbati river basin, highlighting the water quality sampling points and to provide information on the spatial distribution of the



existing levels of water quality parameters. For this thirteen physico-chemical parameters were considered for the analysis. Geographic Information System (GIS) was used to represent the spatial distribution of the parameters and raster maps were created. The analysis were carried out for both the pre and post-monsoon seasons of 2019. Systematic outcomes don't demonstrate any deterioration in the water quality of the water samples collected from 18 sites for both the seasons; all the analyzed parameters were well within the desirable limits recommended by WHO (2011) and BIS (2012) for domestic purposes. The main outcome of the paper, will be helpful for the planners and designers making qualitative assessment of the water problems and devising long-term measures for improving the health of the river especially North-western Indian Himalayan Region.

**Keywords:** *Water quality, spatial distribution, GIS, Indian Himalayan Region, higher altitude.*

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Paper ID – 450

## **Wave Simulation for Optimisation of Breakwater Layout – A Case Study**

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### **Abstract**

The wave data analysis and studies are of fundamental importance for any coastal development especially on the open coast. Wave tranquility plays vital role for deciding the layouts of breakwaters to obtain the suitable operational conditions for berthing etc. Numerical modeling is an efficient tool for wave simulation. This paper presents the wave tranquility aspect for optimization of breakwater layout by using numerical model technique for a site-specific fishing harbour proposal at Kasargod located at the upstream of inlet gut of the River Chandragiri at Kasargod, Kerala on the west coast of India. Under the existing condition, with two training works at site, the problems were faced by the fishermen while maneuvering their trawlers /boats due to high wave actions, adverse flow conditions near the entrance and wave breaking at low tides. In order to ease the difficulties of fishermen, Mathematical wave model studies were conducted to evolve an offshore breakwater of 730m length which would provide adequate wave tranquility. From the considerations of cost, economy and convenience in construction, the proposal of offshore breakwater was modified and further optimized with the help of studies conducted at CWPRS. In offshore region, waves approach with the maximum significant wave height of the order of 4.5 m. The offshore wave data were transformed to a nearshore location by applying MIKE 21 SW model. The optimum layout of breakwater of 700m length was evolved to effect suitable wave tranquility near the entrance and further inside throughout the year against the proposed 895 m length by using MIKE 21 BW model. The present paper describes the methodology and optimization of breakwater layout from wave tranquility point of view by using MIKE21 BW/SW model.

**Keywords:** *Wave tranquility, Deep sea waves, Jetty, Numerical modeling, Predominant wave directions.*

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## Use of Phytoremediation Method for Removal of Hexavalent Chromium by Eichhornia Crassipes

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### Abstract

Out of the several medium of pollution propagation water is considered as a prime medium which manifest the devastating effect of human activities on nature. Due to the ignorance treatment of these hazardous wastes were not done properly and simply dumped on the land or to the water bodies like river and seas which brought an urgent call of destruction globally. These contaminate can easily be entered to the food chain and can cause many health issues in living organisms. The phytoremediation method was introduced in this study to determine the removal of chromium by water hyacinth from synthetic water in the laboratory. The removal potential of the plant was observed on a scale of different parameters, i.e. bioaccumulation kinetics, translocation factor, bio-concentration factor and absorption factor, as well as pH and TDS values. The percentage removal of chromium was initially high and steady then in later stage it decreases. The rate of bio-accumulation initially increases linearly then slows down. The heavy metal translocation from root to shoot was high at high concentrations. The decrease of  $k$  in the graph shows that the water hyacinth's absorption capacity is reduced. Increased plant toxicity can be seen in the  $\log C_t/C_0$  graph, which may have influenced the plant's metabolism. The mathematical model shows nearly same result as the observed value. By this model the removal can be predicted. This method is eco-friendly and economic which can remove sediments, organic and inorganic contaminate. By this technology the water quality can be improved.

**Keywords:** Bioaccumulation kinetics, Bio-concentration Factor, Phytoremediation, Translocation Factor.

## Performance testing of paddle wheel current meters – A case study

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### Abstract

Discharge measurement is of prime importance for management and distribution of water resources. Measurement of local velocities within a gauging section is carried out by conventional rotating element and non-rotating type current meter. Now days, various type of sophisticated portable and non-portable equipments are being used for measurement of velocity like Paddle Wheel, Electromagnetic Current Meter, Acoustic Doppler Current Profile and Contact Free Radar Sensor. These equipment's shall be validated or calibrated as per ISO 3455/BIS 13371 using rating trolley. The paddle wheel is a portable instrument which is continuously in use at site for observing and recording the data related to stream velocity. The paddle wheel under test has Hall Effect type of sensors consisting of a freely rotating wheel/impeller with embedded magnets which is perpendicular to the flow and will rotate when inserted in the flowing medium. As the magnets in the blades spin past the sensor, the paddle wheel meter generates a frequency and voltage signal which is proportional to the flow rate. A magnetic or an optical sensor detects the movement of the paddle wheel and relays the information. It gives direct digital readout of velocity of water at the measuring point. The current meter rating trolley (CMRT) at CWPRS, Pune is having precise electronic drive and speed control system and on board computerized data acquisition and processing system so as to achieve wider speed range of 0.01m/s (10 mm/s) to 6 m/s and uncertainties in



measurements of calibration parameters within 0.1% at 95% confidence level. For performance testing, these equipments are attached to rigid rod by specially developed bracket at the rear side of the trolley. The paddle wheel under test is towed by the trolley at a number of steady trolley speeds. The trolley speed and the corresponding paddle wheel speed shown on the display unit is noted and compared to know the error in measurement. Performance testing has indicated that velocity of the paddle wheel under test is within specified accuracy limit of  $\pm 0.13$  m/s as given by the manufacturer in the velocity range of 0.5 m/s to 3.2 m/s

**Keywords:** *Paddle Wheel Current Meter, Current Meter Rating Trolley, Hall Effect sensor.*

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Paper ID – 460

## Conceptualization and confrontation strategies for water inequity

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### Abstract

As per integrated water management plan we believe that an “equitable water future” is one built on efficiency and conservation. Management of water resources has critical implications in the daily lives of people and above all in economic development and social well-being. The 2030 agenda for sustainable development emphasizes water inequity and sustainable management of water and sanitation for all. Creating an equitable water future means providing all people with access to clean, safe water at an affordable price. The concepts of inequity depend upon how we define inequity in theory and practice or in what space and dimension we want to achieve equality. In addition to this, the issues that constitute equity in accessing through freedom and how accesses to water facilitate the range of capabilities of any society need a critical review at present scenario. Traditionally, water access is measured by the percentage of the population connected to this service and how much supply is being provided but that is not enough to characterize the inequalities. In order to go further analysis of this topic, it is necessary to characterize inequalities that exist in the effective distribution of water among people or households. This article emphasizes identifying significant indicators by scientific method of measurement which will help to identify the methodology best suited for accessing inequality and that can be further utilized by the researchers to understand the current scenario of water inequity and also to plan policy interventions for a better and more equitable future

**Keywords:** *water inequity, conceptualization, water distribution*

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## STATISTICAL ANALYSIS OF LONG TERM RAINFALL FOR THE DISTRICTS OF GUJARAT, INDIA

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### Abstract

An understanding of the spatial and temporal distribution, changing patterns of rainfall is a basic and important requirement for the planning and management of water resources under the changing climate. The present paper intends to evaluate and understand the trends of rainfall in the parts of Gujarat State lying in the western part of India. Rainfall series of eleven districts for the period 1901- 2002 has been used to detect and quantify the trends by using parametric and non-parametric statistical techniques. For detection and quantification of trends in rainfall, Parametric (Regression analysis) and Non-parametric (Mann-Kendall and Sen's Slope) statistical tools have been employed on seasonal and annual basis. The trend significance was tested at 95% confidence level. The results indicate that rainfall at annual scale indicates a decreasing trend at majority of the stations whereas Amreli (0.352 mm/yr), Bhavnagar (0.205 mm/yr) and Kachchh (0.122 mm/yr) districts indicated increasing non-significant trends at 95% of confidence level. During the monsoon season, all the stations except Amreli and Bhavnagar indicated decreasing trend in the rainfall. Winter rainfall indicated decreasing non-significant trends at all the stations.

**Keywords:** Climate change, Trends of rainfall, Sen's estimator, Mann Kendall test, Regression Analysis

## An Overview of Dam Failure and Its Analysis Methods

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### Abstract

A dam is an obstruction that restricts the flow of water. In the present scenario, it has become very important and necessary to store water for the fulfillment of human needs. Dams do not only reduce the chances of flood but also provide water for many activities such as agricultural use, domestic use, industrial use, hydropower generation and navigational activities. As we all know that dams are massive structures thus, they carry risk of failure too. Failure of a dam creates disaster in the downstream of a valley causing loss of human life as well as loss of properties. Therefore, it is now become important to carry out studies to understand the behavior of the flood wave resulting from dam failure and to identify how much area have been breached because of dam failure. It would be very helpful in making an emergency action plan to reduce the loss of property and to evacuate human population. We cannot prevent the flood resulting from dam failure, but we can minimize the losses by adopting proper methods of evacuation. In this paper we have reviewed the results obtained from various numerical models and inundation mapping. We have also discussed about some of the hydraulic models which have been used for dam break study.

**Keywords:** Dams, floods, numerical models, hydraulic models, inundation mapping.



Paper ID – 479

## Hydrological Modelling of Nethravathi Basin Using Swat

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### Abstract

A hydrologic model is a simplification of a real-world system that aids in understanding, predicting, and managing water resources. In this study, an attempt has been made to simulate streamflow on daily and monthly basis, along with calibration for evapotranspiration using satellite-based data in a SWAT model. The SRTM DEM of 90m resolution has been used for the study. The model is successfully calibrated and validated using SWAT-CUP with Sequential Uncertainty Fitting Principle (SUFI2) algorithm for the years 1981-1995 and 1996-20115 respectively. The MODIS ET data was obtained from Application for extracting and Exploring Analysis Samples (AppEEARS). The overall R<sup>2</sup> value obtained is 0.8 and the Nash–Sutcliffe efficiency obtained 0.75 which shows that the SWAT model is good in predicting streamflow in the Nethravathi basin subbasin.

**Keywords:** SWAT, Hydrological modelling, SWAT- CUP

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Paper ID – 492

## Numerical Simulation of Pool Characteristics Formed at Vertical Drops by Volume of Fluid Method

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### Abstract

The pool characteristics at the vertical drops play an important role in water and environmental applications such as dam/spillway designs for minimizing loss to the downstream structures. While detailed experimental work is reported earlier providing insights to the dynamics of vertical drops under varying upstream conditions, a detailed numerical investigation appears to be missing from the literature. In this paper, we report the results generated from an elaborate set of numerical simulations for the dynamics of a vertical drop. The numerical results are then validated against the previously reported experimental results. Vertical drops have a complex water-air interface. Such flows are called free surface flows and require special numerical treatment at the interface for accurately capturing the flow dynamics, such as pool characteristics. Volume of Fluid (VOF) is a well-known numerical technique for estimating the free surface flows accurately. Additionally, turbulence plays an important role in intermixing of the downstream water pool and the falling jet. In this research, we use OpenFOAM's interFoam solver that uses the VOF method and buoyancy modified k-Omega SST turbulence model for capturing the turbulence. We have found that OpenFOAM can be used in fairly accurately predicting the flow dynamics of the pool formed at the vertical drops and by extension can be potentially applied to various water and environmental applications.

**Keywords:** Vertical Drop; Pool Characteristics; VOF; RANS; free surface flow; turbulence; numerical solution.

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Paper ID – 498

## Case Study on Kaddam Dam

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### Abstract

Dams serve multipurpose and versatile benefits to the society such as hydropower generation, water supply, irrigation, flood control and others, but have a high associated risk. There is a need to study the breaking aspects of a dam as it retains enormous water quantities. Thus, there is always a risk of breach formation. Kaddam dam had once failed in the year 1958. It was then reconstructed after increasing the capacity. In this paper, a hydraulic model of Kaddam Dam, in Telangana, is developed on HEC-RAS (by US Army Corps of Engineers) to simulate flood resulting from the failure of Kaddam multipurpose dam in the Telangana state of India. Initiation and propagation of breach into the dam's downstream areas is studied, and inundation map of the downstream submersed areas is prepared. These can be used by the authorities for preparing an Emergency Action Plan (EAP). Digital Elevation Data of the study area is obtained from USGS earth explorer site and is converted into UTM WGS 1984 using the Arc-Map by Arc-GIS software. Erratic precipitation, challenging topographic features, tributaries close to the study area and low resolution (30 m) DEM data were some of the challenges posed during the model's simulation.

**Keywords:** Kaddam Dam; Dam Break Analysis; HEC-RAS; Kaddam River

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Paper ID – 502

## Dam Break Analysis of Hirakud Dam using HEC-RAS

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### Abstract

Dams serve various significant benefits to society, such as irrigation, flood control, hydropower generation, water supply and tourism promotion, and many others. However, they also have a high risk associated with them. There is always a need to investigate the breach aspects of a dam as it retains huge water quantities. In this research paper, a hydraulic model of Hirakud Dam in Odisha is developed on HEC-RAS application (developed by US Army Corps of Engineers) to simulate the flood resulting from the failure of Hirakud multipurpose dam in the Odisha state of India. Hirakud dam was inaugurated in 1957 and continues to be the longest earthen dam in the world. Propagation of flood resulting from dam breach into its downstream areas, especially Burla and Sambalpur, is studied, and an inundation boundary map of the downstream regions is prepared. The Dam Break Analysis plays a vital role in designing an Emergency Action Plan (EAP). Digital Elevation Model Data of the study area is obtained from the USGS earth explorer site and is converted into UTM projection WGS 1984 using the Arc-Map application by Arc-GIS software. Challenging topographic features, vast catchment area, colossal length of the dam, tributaries close to the study area were some of the challenges posed during the model's simulation.

**Keywords:** Hirakud Dam; Dam Break Analysis; HEC-RAS; Arc-GIS; Mahanadi River; Sambalpur; Hirakud

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## **Impact of deforestation and urbanization on extreme temperature and humidity over Brahmani River Basin**

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### **Abstract**

Urbanization and industrialization responsible for change in land use/land cover (LULC) which plays a vital role in studying its impact climate change parameters. The aim of this study is (i) to determine time-series of land use/land cover (LULC) map of the eastern India's Brahmani River Basin that experienced a fast increase in industrialization and deforestation in the recent decade; (ii) Impact of LULC change on extreme Temperature and humidity. The supervised classification method is followed herein to classify the study area with delineated classes such as water bodies; sand; barren/crop land; forest area and built-up area. The study reveals that the major land cover in the study area is dense forest which decreases from 71.70% to 14.85% from year 1975 to 2018. The second major category of land is barren/crop land, which was increased by 30% due to development in agricultural technology, irrigation facilities. The third category of land cover is built-up area which increases by 32.73% from year 1975–2018 due to man-made activities. The least area covered by water bodies which is fifth category of land cover was 0.33% in the year 1975 increased to 1.65% in the year 1999 due to the construction of Rengali Dam and Samal Barrage but subsequently decreased to 0.87% in 2018. Hence, it is verified that the industrialization and development activities cause heavy deforestation in the catchment. It is also found that the decrease in about 56.85% of forest land in just 38 years causes the average maximum temperature and minimum temperature increased to 4.8% and 3.19%, respectively. The relative humidity is found to be decreased by 11.5%. Hence, LULC change especially, deforestation need an urgent control measure to stop global warming and climate change.

**Keywords:** *LULC; Remote sensing; Brahmani River Basin; temperature; humidity.*

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**THEME – VII**  
**HYDROMETROLOGY**



Paper ID – 93

## Postprocessing short to medium range GEFS precipitation forecast in India

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### Abstract

The aim of this study is to improve the skill of Global Ensemble Forecast System's (GEFS) precipitation forecasts over the Indian subcontinent using the Analog and Logistic Regression postprocessing techniques. For the year 2013, GEFS Numerical Weather Prediction Model (NWP) outputs and enhanced GEFS forecasts using postprocessing techniques were verified against the Indian Meteorological Department observed dataset. The techniques were probabilistically and deterministically evaluated using metrics, namely Brier Skill Score (BSS) and Root Mean Square Error (RMSE). Evaluations stated that the use of logistic regression and analog postprocessing method markedly enhances short to medium range (1-15 day) precipitation forecasts in India. The comparison of raw GEFS forecasts and post-processed GEFS forecasts over different regions, in the year 2013 indicates that both the postprocessing methods were able to provide skillful precipitation forecasts in specific regions. During monsoon seasons, both the raw and the post-processed GEFS forecasts were found to be underperforming. The intercomparison of logistic regression and analog techniques showed that the analog method underperforms the logistic regression. The enhanced forecasts using the postprocessing techniques were more reliable and skillful than the raw GEFS model assimilated precipitation forecast.

**Keywords:** Postprocessing, Precipitation forecast, Analog method, Logistic regression.

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Paper ID – 101

## Study on the Impact of Orography on Rainfall in the Western Ghats region of India

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### Abstract

Mountainous terrains are characterized by high spatial and temporal variations in rainfall due the variations in their topography. The present study explores the remotely sensed TRMM 3B42 Version 7 rainfall dataset, to understand the rainfall distribution and its spatial variability existing in the terrain of Western Ghats. ASTER DEM was used in conjunction with 11 years of TRMM data to derive the relation between rainfall distribution and topography. The spatial pattern of rainfall observed in all months of southwest monsoon (June to September) was same, but intense rainfall was much frequent on June and July. It is seen that cascaded topography, gradually rising windward slopes and high peaks are enhancing precipitation. Karnataka's windward side receives maximum rainfall (~28 mm/day) during southwest monsoon among all states in Western Ghats region. It was observed that precipitation intensifies before reaching the summit and then sharply decreases. An inverse relation was obtained between height and rainfall above a particular elevation. Windward slope of the mountains have a significant correlation with rainfall (~0.5) over the terrain, with the most influencing parameters as the length and width of the mountains which in turn decide the spatial extent of blocking of horizontal flow. The information on the relation between rainfall and topography can be further used to modify weather forecasting models and rainfall retrieval algorithms, thereby helpful in better management of rainfall induced hazards and to improve weather prediction in future.

**Keywords:** Orographic precipitation; topography; Western Ghats



Paper ID – 121

## Estimation of Probable Maximum Precipitation using Generalized and Statistical method for Krishna Sub-basin

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### Abstract

Probable Maximum Precipitation (PMP) is a conceptual technique which is widely used to estimate Probable Maximum Flood (PMF) that is helpful in planning, risk assessment, and design of high-hazard hydraulic structures such as flood control dams having large population on the upstream side. The hydraulic structures for water supply, hydropower, and irrigation projects are designed depending upon the risk of failure and the size of the structure. To estimate PMP, there are mainly two methods available, the Generalized method and the Statistical method. In this study, both methods were applied for Krishna Sub-basin or gridded data. In the generalized method, Depth Area Duration (DAD) curves and Moisture Maximization Factor (MMF) are calculated. The Moisture Maximization Factor (MMF) is calculated for identified severe storms for which value ranges from 1.04 to 1.31. In the statistical method (Hershfield method), statistical parameters like  $X_{max}$ ,  $\bar{X}_n$ ,  $\bar{X}_n - 1$ ,  $\bar{C}_n$ ,  $\bar{C}_n - 1$  and Km were calculated. After the calculation of gridded PMP values, an interpolated map is prepared for both methods. The statistical method gives higher calculated PMP values than the generalized method. The estimates of PMP can eventually be used to estimate PMF of the catchment.

**Keywords:** PMP, Generalized method, Statistical method, Krishna Subbasin.

Paper ID – 140

## Probability Distribution and Frequency Analysis of Consecutive Days Maximum Rainfall at Sambra (Belagavi), Karnataka, India

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### Abstract

This case study presents the analysis of the Daily Rainfall Data (1984-2019) of Sambra Raingauge station in North Karnataka. An attempt was made to fit various probability distribution functions to the datasets of 1 day and 2 to 5 consecutive days annual maximum rainfall. The goodness of fit of probability distribution functions were tested by comparing the Chi-square ( $\chi^2$ ) values. Various trendlines were also fitted to the rainfall datasets mentioned above; the best fit was decided based on the coefficient of determination  $R^2$ , however, no single trendline equation was able to describe the entire datasets. The magnitudes of 1 day as well as 2 to 5 consecutive days annual maximum rainfall corresponding to 2 to 100 years return period were estimated by best fit distribution function. It was found that even though Normal distribution had comparatively low Chi-square value, it cannot be used overall for estimation of rainfall values for different return periods of all datasets. Rainfall was also estimated by best fit trendline equation i.e., polynomial 3<sup>rd</sup> order, for all the datasets corresponding to 2 to 100 years return period. It was observed that the rainfall values predicted for 100 years return period for 1 to 5 consecutive days maximum rainfall were extremely high and unrealistic with respect to climate conditions of Sambra region. Further, Chi-square test ( $\chi^2$ ) was conducted between observed and predicted rainfall by different trendlines to ascertain the best fit as determined by  $R^2$ .



**Keywords:** Rainfall, Frequency Analysis, Probability Distribution, trendline equation, Chi-square test

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Paper ID – 141

## Streamflow and Hydrological Drought Trend analysis and forecasting

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### Abstract

The study of streamflow trends and drought trends is significant as it is related to water management. This study analyzes the streamflow and hydrological drought for 45 years in the Netravati river basin in India. Streamflow drought index (SDI) on various time scales (3-, 6-, 9- and 12- months) is used to define the hydrological drought. The Mann-Kendall (M-K) test and Sen's slope estimator at a 95% confidence level are used for the trend analysis. The M-K test on streamflow revealed a decreasing trend in all seasons except in post-monsoon season. Winter and summer seasons showed a significant decreasing trend. SDI revealed a significantly decreasing trend at all time scales. The maximum annual and seasonal departure of streamflow was observed as -64.37% and -69.68%, respectively, in the basin in 2002. An autoregressive integrated moving average (ARIMA) model is built for the basin and used to forecast the mean monthly streamflow. Drought conditions are expected in the future based on the calculated SDI values on a 3-month time scale from the predicted streamflow.

**Keywords:** Mann-Kendall test, Streamflow, Drought, Departure, SDI, ARIMA

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Paper ID – 280

## Evaluation of Rainfall Correction Factor for Jaipur City

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### Abstract

The rainfall data recorded in the discrete-time interval miss the true accumulation of extreme events. The rainfall correction factor (RCF) is used to convert the fixed interval maximum rainfall to true interval maximum rainfall. This study is an attempt to establish the empirical relationship between RCF and sampling ratio (ratio of the duration of interest and the observation time step) for the Jaipur city, India using the observed self-recording rain gauge (SRRG) data of hourly duration. The empirical relationship developed can be used to convert 1-day and 1-hour observed maximum rainfall accumulation into the true rainfall accumulation of 24-hours and 60 minutes respectively. The Extreme value Analysis (EVA) is performed to evaluate the extremes for various return levels. The effect of discretization on the extreme rainfall is analyzed to overcome the underestimation and overestimation of the extreme rainfall values.

**Keywords:** Rainfall Correction Factor, Sampling ratio, Discretization, Jaipur City, EVA

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Paper ID – 282

## Evaluation of Conversion Factor and its Effects on Extreme Value Analysis of Rainfall

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### Abstract

The present study on rainfall analysis for Ahmedabad city is an attempt to quantify the effect of the clock hour correction factor (CHCF) provided in Indian Standard (IS) 5542-2003. The IS code gives uniform CHCF over the entire India. The Generalized Extreme Value (GEV) analysis is adopted for the Annual Maxima Series (AMS) and the computed extremes were compared with Conversion Factor (CF) available in the literature. The study highlights the effect of CF on underestimation or overestimation of the rainfall extremes.

**Keywords:** Conversion Factor, Generalised extreme value analysis, Annual maxima series

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Paper ID – 285

## Event Based Hydrologic Modelling of a Data-Sparse Micro-watershed: Case Study of Thrissur Zoological Park

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### Abstract

A data-sparse watershed is the one where measured rainfall and runoff data are very much limited. Therefore, accurate estimation of peak flood and runoff is a challenging task in such basins. In this study an event based hydrologic modelling using HEC-HMS is employed to solve this problem for an experimental sub-basin of the study area. The proposed site for a Zoological Park Wildlife Conservation and Research Centre at Puthur, Thrissur, Kerala has been selected as the study area. The site is of high social relevance and hydrological studies being conducted here are of utmost importance for management of the available water resources. The watershed is an un-gauged sub-basin where rainfall and runoff data are not available. Observed data sets were collected by field measurements using manual rain gauge for precipitation and float method for runoff. Watershed delineation of the sub-basin is done using Arc hydro tool. The sub-basin is then modelled in HEC-GeoHMS and its various physical characteristics and stream characteristics are determined. Then it is modelled in HEC-HMS. Six different model set combinations have been considered for simulation to determine the best suited combination set for the study basin. Sensitivity analysis, calibration and validation of each model set combination are done. Model performance evaluation using various statistical indices indicates that the combination of the Green-Ampt method as a loss method, Snyder unit hydrograph as a transform method and Recession base flow separation technique have given best simulation results. These parameters have been extended to neighboring subbasins also and a hydrological model for the entire study area has been developed. Runoff simulation for the 2018 flood event is done to determine the maximum value of peak discharge that can occur in the area. This helps in planning an integrated water resources management and Rainwater Harvesting system in the study area. Results of the study indicate that the performance of the model is very good and also the results give an insightful hint for further use of the HEC-HMS model in similar data sparse watersheds.

**Keywords:** HEC-HMS; Data-Sparse micro-watershed; Runoff estimation; HEC-GeoHMS



Paper ID – 296

## Prediction of the discharge carrying capacity of lower Tapi River with the help of HEC-RAS 1-D hydrodynamic modelling

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### Abstract

The small conveyance of the river can lead to floods in the nearby area if the discharge observed is more than its carrying capacity. The frequent flood was observed in the lower Tapi basin. The 1-D hydrodynamic model was developed to predict the discharge carrying capacity of the lower Tapi river with the help of Arc-GIS and HEC-RAS. The model was calibrated for the 1998 flood year and validated for the 2006 flood year. Flow discharge was taken as an upstream boundary condition at the Ukai dam, and water levels were taken as a downstream boundary condition at Nehru Bridge. The calibrated values for Manning's n at both the Mandavi and Ghala stations were found to be 0.035. It was validated for the 2006 flood. The RMSEs and were found to be 1.7671 m and 0.9159 at Mandavi, 1.4219 m, and 0.9313 at Ghala, respectively. Simulated discharge carrying capacity was found close to the observed discharge carrying capacity. The discharge observed at Nehru Bridge was more than the maximum discharge capacity ( $3756.089 \text{ m}^3/\text{s}$ ) at that particular cross-section during the 2006 flood year. The flood inundation took place near Nehru Bridge in 2006, and the maximum water level observed at Nehru Bridge was 12.48 m, which is nearly equal to the simulated water level 12.42 m. It was also observed that generally, the conveyance of the river decreases along the river in the downstream of the Ukai dam. This study could help in flood mitigation and water resources management purposes.

**Keywords:** Hydrodynamic Model, Simulation, Conveyance, Calibration, HEC-RAS.

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Paper ID – 323

## WAVE TRANSFORMATION DUE TO COMPOSITE BREAKWATER SYSTEM

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### Abstract

In the present study, the interaction of oblique monochromatic incident waves with a combination of submerged horizontal porous plate along with a bottom standing vertical barrier is investigated in the context of two-dimensional linear potential theory. The horizontal porous plate enhances the stability and wave absorbing capacity of the structure. An analytical solution based on linear potential theory is developed for the interaction of water waves with the composite breakwater system. The numerical study of the composite breakwater system is performed using the matched eigen function expansion method. The reflection, transmission and energy loss coefficients of the breakwater acting on the horizontal porous plate and vertical barrier is calculated. The effect of structural porosity, width of the structure, plate submergence depth, and wave parameter are examined in detail.



**Keywords:** Composite breakwater; Horizontal porous plate; Vertical barrier; Matched eigen function expansion method; Transmission coefficient.

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Paper ID – 328

## GRAVITY WAVE TRAPPING BY STRATIFIED POROUS STRUCTURES COMBINED WITH SUBMERGED POROUS PLATE

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### Abstract

The present study deals with the wave trapping by a combination of stratified porous structure of different densities along with vertical barrier and submerged horizontal plate using the linearized theory of water waves. The porous structure thickness is considered to be significant and the thickness of the plate is negligible when compared to the incident wavelength and water depth. The study is performed to analyse the effect of different porosities of the stratified porous structure along with vertical barrier and submerged porous plate. The angle of incidence, friction factor, depth of submergence of porous plate and porosity of the structure is varied to analyse the wave reflection coefficient, transmission coefficient, dissipation coefficient, wave force on the submerged porous plate and the porous structure. The numerical commutation is carried out using the mode-coupling relation and the matched eigenfunction expansion method. The change in the confined region is studied for better wave trapping by the breakwater system. The present study will be helpful for the design of an efficient breakwater system for the wave energy dissipation.

**Keywords:** Stratified porous structure; Porous plate; Vertical barrier; Wave dissipation; Reflection and transmission coefficient

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Paper ID – 332

## Development of Rainfall Intensity-Duration-Frequency (IDF) curves of Ganjam District, Odisha, India

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### Abstract

One of the major challenges faced by hydrologist is inadequacy of hydrological data such as rainfall to properly design, operate and plan water resources projects against extreme rainfall event. Such data would be needed for the development of Rainfall Intensity-Duration-Frequency (IDF) curves for design of drainage system or any water resources project in urban systems. For the appropriate design and planning of urban drainage system in an area, Intensity Duration Frequency (IDF) curves for given rainfall conditions are required. Hence, development of rainfall Intensity-Duration-Frequency (IDF) relationship is a primary basic input for the design of the storm water drainage system for the populated cities of Ganjam district of Odisha state. The rainfall depths derived from the intensity duration frequency relationship is being used by water resource managers for planning, designing and operation of water resource related projects. To ascertain the hydrologic risks, assessment of extreme precipitation and establishment of IDF curves are important. Daily rainfall data were collected from the Irrigation Department of Ganjam district for seven major towns e.g., Chhatarpur, Ganjam, Purushottampur,



Kavisuryanagar, Kodala, Khalikot and Sorada, for a period spanning over 24 years (1995-2018). The IDF curves were generated using the Gumbel's Extreme Value Type-1 distribution. The rainfall intensity values were calculated for duration of 0.25hr, 0.5hr, 1hr, 2hr and 24hr with periods of 2, 5, 10, 20, 50, 100 and 200 years. The Rainfall Intensity-Duration-Frequency (IDF) curves were developed for the seven important towns of Ganjam district which can be used for the design of drainage structures and other water resources structures.

**Keywords:** *Rainfall; IDF, Ganjam, Intensity, Return period*

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Paper ID – 349

## **Investigation of Variability of Meteorological Dry/Wet Conditions and its Implications in Chennai, India during 1960–2020**

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### **Abstract**

This paper presents a quantitative investigation of the variability of meteorological dry/wet conditions of the Chennai metropolitan area during 1960–2020 by using the standardized precipitation evapotranspiration index (SPEI). The SPEI is computed based on the daily observations of meteorological stations across the catchment covering the districts of Chennai, Thiruvallur, Kancheepuram and Vellore. The SPEI is computed for the timescale of 1, 3, 6, 12, 24 and 48 months that display the meteorological dry/wet spells for several severe drought and flood events that occurred during the last 6 decades. The possible impacts of climate change in terms of the changing temperature and precipitation patterns were also considered. There has been a stark change in land use patterns, population stress, abuse of natural resources and climate in the developmental phase of the landscape. Climate induced impacts like droughts, floods, heavy rains and winds are becoming increasingly evident in the landscape. The city of Chennai faces summer water crisis on one end and monsoonal flood disasters on the other end. Major results show that the occurrence of dry/wet condition has erratically changed in the recent two decades, especially the subsequent wet and dry spells from 2010 to 2020. In addition, the possible impacts of temperature variation on dry/wet conditions were also examined by comparing SPEI and standardized precipitation index (SPI) at multiple timescales during the study period. The results in this paper will contribute to develop management strategies that build resilience to the water mediated risks in the Chennai metropolitan area.

**Keywords:** *Chennai; climate change; droughts; floods*

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Paper ID – 354

## Development of Soil Water Retention Curve in Lower Kosi River Basin, India using Transfer Function

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### Abstract

Soil water content is an essential variable in irrigation, crop water requirement, and flood inundation modelling. It controls the proportion of rainfall that infiltrates into the soil and causes runoff over the land surface. Experimental methods and empirical models to develop soil water retention curve and to predict soil water content are in practice. In the present work, soil samples from fourteen locations of lower Kosi basin, India have been collected and soil water retention curve (SWRC) along with field capacity and wilting point has been derived. Ten commonly used equations-based transfer function (TF) have been tested for their applicability to simulate SWRC and obtain field capacity as well as wilting point using air entry pressure, residual water content, saturated water content, pore size distribution index, and various coefficients. The performance of all the ten TF equations has been evaluated using, root mean square error (RMSE), mean absolute error (MAE) and linear correlation coefficient (r). The equation developed by van Genuchten (1980) showed best results. Moreover, a refined model based on non-linear Log-normal distribution has been developed using the properties of soil in terms of porosity in addition to other variables used earlier. The use of physical properties in all TF function are omitted. The refined model minimizes error estimates and improves correlation between observed and computed soil water content.

**Keywords:** Field capacity; flood inundation; soil water content; wilting point

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Paper ID – 362

## Spatio-temporal Analysis of Extreme Temperature Indices of India Using Non-parametric Tests

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### Abstract

Understanding the changing pattern of climatological extremes is important for management of natural hazards resulting from them. Analyzing the temporal variability of trends and the changes exhibited by extreme temperature indices are of immense importance as they are the prime indicators of global warming. This study performs the spatiotemporal variation in the trend and change point year of four prominent annual extreme temperature indices (ETI) across India. The ETIs at annual scale namely Cold Spell Duration Index (CSDI), Warm Spell Duration Index (WSDI), Number of summer days (SU), Number of tropical Nights (TR) are determined based on daily maximum and minimum temperature datasets of 1°x1° spatial resolution of 1951-2015 period. The trend analysis using Mann-Kendall (MK) test revealed that WSDI series of 55 % of the grid points shows significantly increasing trend whereas the time series of CSDI, SU and TR show significantly increasing trend only in 6.2 %, 23 % and 9.8 % of the total grid points. Further, the temporal variability of trend of different indices are estimated by partitioning the different time series with respect to the Pacific global climate shift of 1976/77. The analysis revealed an increase in the trend in the WSDI and TR series of post climate shift period. A decrease in the trend is noticed in the CSDI series, while the difference in trend pattern was relatively less in the SU series. Further, the four ETIs in each grid points were subjected to Pettitt test for the single change point detection. The change point analysis showed that maximum number of grids displayed a change in the decade of 1981-1990 in



SU and WSDI series. The CSDI and TR series indicated a change during the decades of 1961-70 and 1991-2000. In general, the different ETIs of India exhibit diverse pattern in the properties of trend and change point in the time series.

**Keywords:** Mann Kendall test; Temperature; Trend; Change Point; spatial variability; temporal variability.

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Paper ID – 378

## Rainfall Interception from the Dual Canopy of Coffee Plantation in the Western Ghats

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### Abstract

This paper describes the canopy interception of rainfall during the monsoon season. Field measurements were carried out using fifteen funnel type ordinary rain gauges in an area of 30m x 30m to measure the through fall. Rain gauges were placed at different locations to account for variability of vegetation thickness (Leaf Area Index). Through fall measurements were compared with Gross rainfall measurements made at an open space near to the plot. The results showed that thicker canopies intercept more water whereas at the edges of the plants interception is less. The average through fall to gross rainfall ratios varied from 0.36 to 1.06 for different rain gauges and the overall average of the ratios for the season was found to be 0.82. From the study it can be concluded that evaporation losses due to interception forms the major loss of the water balance.

**Keywords:** Interception, Evaporation loss, through fall, Agrarian forest.

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Paper ID – 403

## Evaluation of precipitation-recharge relationship and groundwater resilience of catchments in Madhya Pradesh

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### Abstract

Groundwater is the water stored beneath Earth's surface in soil and porous rock aquifers. It accounts for as much as 33% of total water withdrawals worldwide. Over two billion people rely on groundwater as their primary water source, while half or more of the irrigation water used to grow the world's food is supplied from underground sources. Thus, it is important to understand the response of groundwater system under the changing climate. In the present study, we aim to attempt to understand the precipitation- recharge relationships (groundwater sensitivity) with the application of *abcd* water balance model in five catchments, lying in Madhya Pradesh. Here, a modern



approach NSE and its components (Bias, variability) is used to evaluate the performance of hydrological model. Further, based upon the performance of the catchments quantification of groundwater sensitivity i.e. change in groundwater recharge with change in precipitation and resilience i.e. to explore the changes in groundwater resilience is carried out. The results of the study found that 4 out of 5 catchments performed well on the evaluation criteria and further these catchments are used for the evaluation of groundwater sensitivity and groundwater resilience. The mean groundwater sensitivity ranges from 0.20 to 1.4. And, the catchments Mataji, Gadarwara, Mohgaon show a decreasing trend in groundwater sensitivity while Kagaon encompass an increasing trend for the period 1989-2011. Moreover, the mean resilience index ranges from 1.7 to 3.2 during 1993-2007, where Gadarwara and Kagaon show a significantly decreasing trend. The potential resilience of groundwater to climate variability in these catchments that is revealed by these precipitation–recharge relationships is essential for informing reliable predictions of climate-change impacts and adaptation strategies.

**Key words:** Groundwater; Resilience; Critical slowing down theory; hydrological model

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Paper ID – 473

## Indian Teleconnection of Ocean Atmospheric Phenomena on Precipitation

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### Abstract

Large-scale ocean-atmospheric phenomena or climatic oscillations have a strong influence on Indian Summer Monsoon Rainfall (ISMR). ISMR has both temporal and spatial variability that causes frequent droughts and floods in various parts of India. The variations in ISMR have significant effects on agriculture, annual water availability, power generation, and the country's economic growth. This study examined the variation of ISMR due to different ocean atmospheric phenomena, such as El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO) and Atlantic Multi-decadal Oscillation (AMO), in different regions of India. The goal of the study was to analyse the individual and coupled effects of climatic oscillations on spatiotemporal variations of ISMR. A non-parametric statistical method namely Wilcoxon Rank Sum (WRS) test was used to identify the teleconnection between ISMR and global atmospheric circulations. The individual analysis shows that ENSO has a major influence on changing the spatial pattern of ISMR than PDO and AMO. The coupled analysis was performed to understand how the different phases of PDO and AMO interacted with different phases of ENSO on ISMR in various regions of India. When El Niño associated with the negative phase of AMO resulted in a 15% increase of ISMR in Northeast India, which is a deviation from normal El Niño phase. The results of this study can be used as a guideline for making better decisions on water resources management.

**Keywords:** Climatic oscillation, ISMR, ENSO, AMO, PDO.

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Paper ID – 480

## **Analysis of rainfall trends and extreme precipitation indices in a humid tropical basin.**

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### **Abstract**

Understanding the precipitation pattern and trend of a region is very important in water resources planning and management. The trend in the historic rainfall time series and extreme precipitation indices in the Achencoil basin Kerala state is evaluated using Mann Kendall test and Sen's slope analysis. Analysis of annual and seasonal rainfall showed an increasing trend in the area. Annual and monsoon rainfall showed a significant rise in two out of the four grid points considered. Two extreme rainfall indices RX1day and RX5day have been considered in the study. RX1day experienced increasing trends in all points with a significant rising trend at Grid D. RX5 day showed an increasing trend at two grid points and decreasing trends at the other points, all are insignificant. The results highlighted the presence of a significant trend in rainfall at various scales, which demands the need for detailed analysis of climate change in the region.

**Keywords:** *Achencoil basin, Mann Kendall test, Extreme rainfall indices*

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**THEME-VIII**

**HYDROMETEROLOGY, WATER RESOURCES  
MANAGEMENT AND SOFT COMPUTING**



Paper ID – 412

## Frequency- Duration Assessment of Atmospheric Rivers at Global scale

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### Abstract

Atmospheric rivers (ARs) are filamentary regions with high water vapor flux of low troposphere. These ARs represent narrow rivers like structure in the atmosphere and land falling of these ARs can produce a massive amount of precipitation if substantial orography is available. This huge amount of moisture can produce either beneficial rain to some regions or can create extreme events of flood or drought. Therefore, it has a great influence over the economy and social stability of any region. As a climatologist and meteorologist, it is very important to understand the pattern of moisture transport in the atmosphere. In changing climate with global warming, it has become even more important to comprehend the varying spatial and temporal distribution of ARs. There have been many algorithms developed by the researchers and scientists for the identification of ARs based on the geographical region concerned and the local climatology. The integrated water vapor transport (IVT) based algorithm has been popularly adopted and appreciated by various researchers for the detection of ARs, similar algorithm has been adopted here. The threshold for mean IVT is 100 kg/m/sec has been adopted for taking consideration of global climatology. The frequency and duration of detected ARs can define the risk associated with ARs at a particular geographical location in a specific time. The frequency analysis of land falling ARs shows presence of ARs in all major continents and decadal analysis from 1979 to 2018 shows that ARs is more consistent where the frequency of land falling is more. The ARs were found more frequent at the west coast throughout the globe.

**Keywords:** Atmospheric river; Integrated water vapor; land falling AR; global climatology

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Paper ID – 418

## A review on study of hydrodynamics and sustainable model of raceway Pond

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### Abstract

Algae growth raceways ponds are open channel frameworks utilized to create the growth of algae utilizing daylight and source of supplements to flourish. These frameworks are getting expanding consideration for their potential to be utilized as a reasonable and feasible source of light nutrition nourishment, by the cosmetic industry, or indeed as an elective source of biofuel. Keeping the fact in view in order to realize financial possibility and empower this change, the efficiency of this framework has to be considerably progressed. Mixing of gases and nutrients by turbulence inside the raceway plays a central part within the productivity of the framework. Blending avoids algae growth from settling onto the foot of the raceway, guarantees suitable level of exposure to daylight and nutrients and increase gas diffusion and trade between the raceway and the atmosphere. This review paper summarizes detailed study of mixing processes within existing raceway ponds, recent practices in optimum



production of biomass keeping physical, biological and environmental parameter. Pond liners for large-scale cultivation of algae for biofuels and byproducts are a significant source of capital cost and greenhouse gas emissions, both of which can be reduced by using unlined ponds. The review also focuses on potential use of sealant mechanism on productivity of pond. The experimentation and numerical modeling using various CFD model will be summarized to study the hydrodynamic behavior of raceway ponds which includes hydrodynamic characteristics of raceway ponds, evaluation of hydrodynamic and mass transfer capacities of pond. This review concludes how the study of various parameter (mixing process, optimum production of biomass, sealant mechanism, and hydrodynamic behavior) can be supportive to plan a profoundly profitable raceway pond based on microbial culture framework.

**Keywords:** Raceway Ponds, Hydrodynamic, CFD, Mass Transfer, Biomass, Sealant

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Paper ID – 431

### **Dam Break Analysis Using HEC-RAS: A Case study of Kadana dam**

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#### **Abstract**

Dams are essential to produce more crops and to generate clean hydropower. In a largely populated country like India, dams play important role in achieving zero hunger and to provide clean water and energy. Safety of such structures is utmost priority for state authority as the failure of the dams lead to catastrophe in downstream areas. Dam break analysis are done to for each large dam to investigate the dynamics and spread of flood wave caused by dam break. In this study a numerical experiments of dam break are demonstrated using HEC-RAS. Study area selected for this study falls in Lower Mahi basin and it starts from Kadana reservoir to 30 km downstream of Wanakbori weir on Mahi River. Flow geometry of model area is generated in HEC-GeoRAS and 1D HEC-RAS Model is constructed for unsteady flow simulation. The overtopping failure is created with two events as 2006 flood and design flood. Three breaching scenario is simulated for each event named as 2006 flood and design flood. The maximum discharges, water levels, velocities and flood travel times at different locations of the river downstream of the dam are analysed. Inundation mapping is also carried out using RAS Mapper. The inundated area under dam break condition is found slightly more than that without dam break. The results from this study can be further useful for development of EAP and Restriction of Construction in flood prone zones. HEC RAS is found to be very useful tool for investigating different scenarios of Dam break.

**Keywords:** Dam break, HEC-RAS, Mahi River, Kadana Dam

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Paper ID – 437

### **Efficacy of Nano particles of Flyash on its permeability**

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#### **Abstract**

The seeping of water through the body and below the base of hydraulic structures is of paramount importance for civil Engineers in design of such structures. A huge amount of money is generally spent in India for seepage control. On other hand, fly-ash, resulting from the burning of pulverized coal, available in huge amount as a waste product from thermal power plants, causes environmental pollution and storage problem. Recent development of Nano-technology and its possible application in various fields of engineering and science are reported in literature. The application of Nano-particles in the field of water resource engineering is least attempted. In the present study, a combination of various sizes of fly-ash mixed in varying percentages by weight was subjected to permeability test. The mixture giving the least permeability was mixed with fly-ash Nano particles ranging from 5%, 10%, 20%, 30% and 40% by dry weight of mixture to get a further reduction in the value of permeability. This research paper reports the efficacy of Nano particles of fly-ash collected from Harduaganj thermal power station as an additive in reducing the permeability of fly-ash. The low permeable mass so developed can be used in canal and embankments to control seepage.

**Key words:** Fly ash; Nano-particle; Permeability; Scanning Electron Microscope

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Paper ID – 446

### **Review on scour depth modelling of bridge pier**

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#### **Abstract**

Scouring can be defined as a process due to which the particles of the soil or rock around the periphery of the abutment or pier of the highway bridge spanning over a water body, get eroded and removed over a certain depth is called as scour depth. Scouring usually occurs when the velocity of the flowing water increases or crosses the limiting value that the soil particles can easily handle. In this paper clear-water scour and live-bed scour are studied. Clear-water scour occurs when bed material is not in motion while live-bed scour occurs where upstream shear stress is greater than threshold value and the bed material start moving. To model scour depth, many researchers have used regression analysis and various soft computing techniques such as ANN, ANFIS, GEP, etc. To model scour depth various independent parameters like scour depth, mean sediment size, initial bed slope, pier width, flow depth, Froude number, pier diameter etc have been considered by many researchers. This paper suggests most important influencing parameters and suitable model to predict bridge pier scour depth with better accuracy.

**Keywords:** Scour depth; GEP, non-dimensional parameter; ANFIS; Froude number

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Paper ID – 447

## Review paper on Flood Routing

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### Abstract

Flood routing is an important aspect of hydrology which progressively determines the timing and magnitude of flood wave along a river stream. Most river reaches are ungauged, and a methodology is needed to estimate the rates of flow, at specific locations in streams where no measurements are available. Accurate information of the flood peak attenuation and the duration of the high-water levels obtained by channel routing are of most importance in flood forecasting operations and flood protection works. Study usually implements Muskingum method to estimate the inflow and outflow discharge at the riverbank. The parameters of Muskingum method are determined using three methods graphical method, least square method and regression analysis approach. The assessment of results is compared from the above three methods. Muskingum-Cunge method can be applied to route floods in ungauged catchments using derived variables in the different Indian catchment area. Other flood routing models are level pool model and modified-Pul's model can be used to evaluate the discharge in the downstream section of the river. Muskingum and level pool model represent linear relationship between measured outflows and predicted outflow. The storage index and the techniques of flood routing may also be used in computing and evaluating stream flow records. This paper will summarize the different routing method which are best suitable for Indian river catchment case.

**Keywords:** Hydrology; flood routing; Muskingum-Cunge method

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Paper ID – 485

## Analysis of Squeezing Problem in tunnel: A Case Study of Middle Modi Hydroelectric Project, Parbat, Nepal

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### Abstract

Squeezing ground in underground construction will face several engineering challenges in which the complex geology presents a series of tunneling problems. A squeezing action can be triggered when fragile rocks are exposed to high stresses. The headrace tunnel Middle Modi Hydroelectric Project (MMHEP), Parbat, Nepal has been taken as a case study, which was excavated by drill and blast in arduous ground conditions with squeezing behavior. The interest of the present paper is centered upon the first approximately 160m of the tunnel, starting from Chainage 0+900m to 0+930m and from 1+200m to 1+400m, of total length 2+600m due to which the tunnel cross-section has narrowed down. The tunnel wall closure along this stretch is well over 30cm and the maximum recorded closure exceeds 65cm. Different methods (Empirical, Semi-empirical, Analytical, and 2D finite element numerical modelling program) are used for assessment of the squeezing phenomenon. The result of the analysis is that the degree of squeezing in a tunnel can be predicted if more than one method is employed to verify mechanical properties of the rock mass. Following a series of preliminary back analysis, performed under axisymmetric conditions this paper analyses the squeezing phenomenon along the tunnel stretch through the



evaluation of rock mass properties with appropriate support system design and its support pressure estimation for the purpose of addressing difficulties exhibited in the extreme rock mass deformation during the excavation phase.

**Keywords:** *Squeezing, Middle Modi Hydroelectric Project, Tunnel Closure, Support pressure, Plastic zone.*

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Paper ID – 487

## **Research on the impact of heavy metals on surface water quality of Brahmani River**

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### **Abstract**

River water has been the lifeline for the civilization that flourished over the past thousands of years. As there is river, there is contamination of river which is as old as civilization. After the post-industrial revolution period (1990) in India, there is a gradual increase in the pollution levels of the river water because of the discharge of untreated heavy metals into the river thus making the river water toxic both for humans and animals. This study evaluates the geospatial metal distribution and extent of contamination of heavy metals such as temperature, pH, electrical conductivity, sodium, nitrates, magnesium, calcium, chlorides, sulphates, lead, ferrous and chromium in surface water of the Brahmani river. This above-mentioned study was done to make water quality parameters comparison with the local (BIS) and global (WHO) average values. The last thirty years water quality parameters of Brahmani river were collected from central water commission (CWC) which were collected at panposh and comparison was made with the experimental values. Rourkela, being the industrial hub of Odisha state there is a high chance of industrial waste production which is to be disposed into river. Over the last decade, there is not much study done on the contamination levels of river Brahmani. So, there is an urgent need to study the increasing levels of the pollution in Brahmani river.

**Keywords:** *Brahmani river, Geospatial metal Distribution, Chromium, lead.*

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Paper ID – 501

## **Application of Multi Gene Genetic Programming for Prediction of Discharge in Open Channels with Vegetation**

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### **Abstract**

Flow rate or discharge is a basic but very essential parameter that helps to quantify the flow in open channels or natural river streams. Stage-discharge relationships, flood forecasting and modelling, routing studies and other practical hydraulic applications justifies the necessity of discharge estimation. Numerous methods using different



experimental or analytical approaches have been proposed to predict discharge in open channels for various flow conditions and channel geometry. To bolster the investigation on vegetative channels, this study aims to develop an effective and precise model that would define discharge for channels with any type of vegetation, using modern-day computational techniques. River discharge depends on several parameters such as- geometrical parameters (channel dimensions, bed slope), hydraulic parameters (Froude's Number and Reynold's Number) and vegetation parameters (vegetation density, submergence ratio, vegetation dimensions). A large dataset incorporating all these parameters is compiled by collecting data from previous laboratory experiments. This data served as input for the development of an accurate model using Multi Gene Genetic Programming (MGGP), an advanced Soft Computing technique based on the principle of evolution and genetics. From this extensive dataset, testing dataset is segregated and upon validation it yielded good correlation and minimal error for the predicted discharge. This study also helps us to realize the immense capabilities of advanced computing techniques and their future scope in hydraulics.

**Keywords:** *Genetic Programming; Froude's Number; Reynold's Number; Vegetated Channel; Vegetation Density; Submergence Ratio*

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**THEME-IX**

**HYDRAULICS, HYDROLOGY AND WATER QUALITY  
MODELLING**



Paper ID – 031

## Evaluation of Design Wind based on Projected Cyclonic Conditions

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### Abstract

The assessment of impact of climate change on design wind is necessary in view of growing concerns of the designers of ocean structures about safety of their designs. This study is aimed at evaluating the design, i.e., 100-year return, wind speed at twelve major port locations of India considering future cyclones affected by climate change. This work goes beyond earlier attempts in this regard in which future cyclonic events were not considered. The historical and futuristic wind data of around 3 decades each were derived from a global climate model: CanESM2 that was earlier run for two global warming scenarios called representative concentration pathways (RCP)-4.5 and RCP-8.5. This wind information is however devoid of the effect of cyclones. Hence historical cyclones were embedded in these wind data and annual maximum wind speeds were evaluated. As regards the futuristic conditions, the annual maximum wind from the climate model was increased by 7 and 11 % until the end of this century to include future cyclonic winds, which was as per earlier studies reported in the literature. The generalized extreme value distribution was fitted to historical as well as futuristic sets of data and 100-year return wind speeds were extracted. The results showed that the design wind derived from futuristic conditions could be higher or lower than the one based on historical conditions depending on the location of interest. This study thus emphasizes site specific evaluation of design wind under changing climate.

**Keywords:** Climate change; tropical cyclones; generalised extreme value distribution

Paper ID – 033

## Head loss prediction at the water tunnel and shaft junction

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### Abstract

In fluid flow through water tunnels of storm water system, friction losses consist of the major losses and minor losses. Generally, minor losses are ignored for the system head calculations as they are considered negligible. Minor losses are calculated using the standard resistance factor and velocity head. However, in case of water tunnels and shaft junction, the losses could not be calculated, as no specific literature available. There are two approaches to estimate the losses. In first approach, losses at each tunnel junction are estimated with entry and exit loss formulation while in second approach they are considered as negligible. Both the approaches lead to deviations from actual losses especially when number of intermediate tunnel junctions are more. In first approach, the predicted head loss is higher while in second approach, it predicts lower head loss. In case of the long tunnels, carrying water from the farthest point of catchment area to pump house, the number of junction points can be many. Hence, total loss across the junctions would be significant. In this paper, an attempt has been made to find out the friction losses across the tunnel and shaft junction using CFD analysis technique. The paper demonstrates that these losses would lead to incorrect estimation of pump suction water level and result in pumping operation away from its best efficiency point (BEP). It has been found that deviation in predicting such losses could be detrimental for the estimation of water levels and sump bottom levels.

**Keywords:** Minor head loss; Tunnel and shaft junction; Computational Fluid Dynamics; Submergence; Pump.



Paper ID – 052

## Significance of Classification and Regression Tree (CART) Models in the Prediction of River Water Quality

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### Abstract

Watersheds are increasingly becoming prone to pollution due to wastewater discharge from the various point and nonpoint sources, for example, run-off from rural areas and combined sewer overflows (CSOs) from urban areas. Such discharges from various sources contaminating the Upper Green River watershed in Kentucky, the USA over the years. It is important to comprehend water quality parameters quantitatively to characterize the water quality status of streams in the Green River watershed. Multiple studies are found in the prediction of river water quality using multivariate statistical techniques such as regression, factor analysis, cluster analysis and also using artificial intelligence methods such as neural networks. In this study, a novel attempt has been made to predict the status of the quality of Green River water with predictive capabilities of classification and regression tree (CART) model. CART is a simple model to understand and interpret. Visualization of results is easily done with the help of trees. CART model has been developed to predict the concentrations of fecal coliform, and turbidity in the Upper Green River watershed. The paper concludes with an analysis of the results of the classification and regression tree (CART) models and insights from them.

**Keywords:** Water quality; Land Use Factors; Classification and Regression Tree (CART); Fecal Coliform; Turbidity

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## IoT enabled greywater management

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### Abstract

Life begins with water. We the human beings are expert in polluting the resources, but very poor in conserving and managing the resources. Many of the water sources have been polluted and water crisis slowly metastasized all over the world. It is highly essential to reclaim and reuse wastewater to avoid the water being claimed as an extinct resource. Greywater is the wastewater generated from bathrooms, laundry washing, kitchen sinks and it does not include toilet wastewater. Reusing and recycling of greywater will reduce the water demand to a greater extent and in particular, it is highly effective in urban areas where the demand for water is more and pricey too. Nowadays smart solutions and technologies are escalating throughout the world. The idea of incorporating smart solutions in wastewater management will make water systems more interconnected and intelligent. This smart system with its function of sensing, actuation and control allows understanding the needs and performs the desired actions with lesser human intervention. Wireless Sensor Networks (WSN) and the Internet of Things (IoT) technologies are used to monitor and control the wastewater systems. IoT enabled greywater management system uses sensors to retrieve the greywater data, gateway communication to transmit the data to the cloud server, data analytics and computing are performed in the cloud server and necessary actions will be taken based on the sensory data. IoT enabled greywater management system provides us real time monitoring and managing of water resources to make it sustainable for the future.

**Keywords:** Greywater; recycle and reuse; sustainable resources; Internet of Things; IoT

## Effect of flow depth and velocity on the local scouring around rectangular bridge pier on gravel bed

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### Abstract

Scour around a bridge pier (local scouring) is a major concern in the design of bridges, as it may lead to bridge failures. Local scouring around bridge piers can be affected by flow characteristics, pier shape, bed material and channel properties. Large number of research works has been done for the estimation of scour characteristics around a cylinder on the fine and medium sand. However, scour characteristics around elongated piers on the gravel bed and the quantification of the effect of flow parameters on local scour is still not investigated thoroughly. This study, experimentally investigated the effect of flow characteristic (velocity and flow depth) on the local scour around a rectangular bridge pier on gravel bed ( $d_{50} = 6.8\text{mm}$ ). The width and length of the pier were 0.03 m and 0.15m, respectively. Three flow depths and three different flow velocity levels were considered in this study. The results showed significant effects of approach flow parameters on the scour characteristics around bridge pier. Equilibrium scour depth increased with the flow velocity whereas it decreased with the flow depth. Instantaneous velocity data was also collected using Particle Image Velocimetry (PIV). Flow hydrodynamics such as turbulent



kinetic energy (TKE) and vorticity analysis was also performed to get more insight on the observed scour characteristics.

**Keywords:** *Local scour; Rectangular bridge pier; Gravel bed; Particle Image Velocimetry*

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Paper ID – 109

## **Impact of choice of different runoff and river routing schemes in JULES land surface model: A case study from Damodar river basin**

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### **Abstract**

Land surface models (LSMs), a connection between atmosphere and hydrology developed for representing the exchange of energy, water, and carbon fluxes between land and atmosphere. Runoff generation and river routing schemes are integral part of LSMs for the simulation of runoff and river discharge, apart from that it decides and regulates the soil moisture, energy flux, and crop, vegetation growth dynamics, carbon and nutrient transport in river channels depending on the complexity of LSMs. Thus, these schemes play a significant role in making critical management decisions based on LSM simulations for future water security related issues. The present study aims at the evaluation of two runoff production schemes (TOPMODEL and PDM) and two river routing schemes (TRIP and RFM) in the Joint UK Land Environment Simulator (JULES) LSM and the analysis of the effect of these schemes on streamflow simulation of the Damodar river basin, India. The model is simulated for the period of 2004-2008 at a spatial resolution of 0.5° with six configurations: (i) JULES-BASE with TRIP; (ii) JULES-BASE with RFM; (iii) JULES-TOPMODEL with TRIP; (iv) JULES-TOPMODEL with RFM; (v) JULES-PDM with TRIP; and (vi) JULES-PDM with RFM. Model simulated daily streamflow hydrograph are compared with observed data at two gauging stations, Phusro and Damodar Bridge, of Damodar river basin. RFM river routing scheme in all three model configurations (JULES-BASE, JULES-TOPMODEL, JULES-PDM) greatly underestimates the streamflow at both the gauging stations and produces low Nash-Sutcliffe efficiency (NSE) co-efficient and large error in terms of root mean square values (RMSE). TRIP river routing scheme performs well in comparison to RFM river routing scheme and also shows marked improvement in NSE and RMSE values in case of JULES-BASE, JULES-TOPMODEL, and JULES-PDM. In contrast to PDM, TOPMODEL performs better than PDM and also shows higher NSE and lower RMSE values. Finally, the results indicate that the proper choice of runoff and river routing schemes is essential in the hydrological simulations of land surface models especially in base flow dominated regions as it also decides accuracy of the timing and quantity of freshwater flux simulations.

**Keywords:** *JULES; TOPMODEL; PDM; TRIP; RFM; runoff generation scheme; river routing scheme*

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## Trend Analysis of meteorological drought for Peninsular India region

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### Abstract

Drought is a naturally occurring disaster which occurs in a region due to deficit of precipitation for a prolonged period. Drought occurs in all climatic zones and causes a huge impact on the economy, agriculture, health and environment, among others, leading to other cascading vulnerabilities. Drought analysis has become a major role in determining the occurrence of drought in any region. The study aims to analyse the drought trend using the time series Standardized Precipitation Index (SPI) in Peninsular India region. The technique applied to the present study is based on the non-parametric Mann-Kendall (MK) test to detect the drought for the Peninsular India region. The Peninsular region has a tropical climate and depends on monsoon for rainfall. The rainfall in Peninsular region is unevenly distributed from region to region ranging with an average from 300mm- 2500mm annually. Recent studies indicate that some parts of this region had been experiencing a widespread drought condition and millions of people are facing high to extreme water crisis. A clear indication from the study shows that during the non-monsoon period most of the region suffer from shortages of water supply and also affects agriculture. The study of drought trend has become an important sign to understand the drought events in preparing and managing the impact caused due to drought.

**Keywords:** Drought, Standardized Precipitation Index (SPI), Mann-Kendall (MK) test, Trend Analysis.

## Indication about the bio-optical status of a water body from its spectrum measured by Sentinel 2 MSI

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### Abstract

Attempts for utilizing freely available Multi-Spectral Satellite (MSS) imagery as a rapid kit for water quality monitoring has been prevailing since the advent of satellite remote sensing. The better spatial and spectral resolution of Sentinel 2 MSI imagery opens up an avenue for research in its utilization for studies in inland and coastal water bodies. The use of satellite imagery is limited by the uncertainty caused by atmospheric interference. Successful retrieval of reliable information from these imageries requires them to be atmospherically corrected. Though various algorithms are available for atmospheric correction, their efficiency depends on various factors. The present study attempts to compare the bottom of the atmosphere (BOA) spectrum of Sentinel 2 MSI imagery corrected by three algorithms Sen2Cor, Acolite and C2RCC. The comparison of these methods indicated that C2RCC provided a more realistic spectrum based on the shape of the spectrum available from the literature. The study of variations in the spectra of different areas in different seasons is attempted here as an easy and quick way to throw light into the optical status of the water body

**Keywords:** Atmospheric Correction Algorithm, Sentinel 2, C2RCC, Sen2Cor, Acolite, Spectrum



## Probabilistic Human Health Risk Assessment of heavy metals in River Gomti in Lucknow city, India

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### Abstract

The current study evaluated the health risks associated with the consumption of water from River Gomti contaminated with heavy metals. The river water is used for drinking and irrigation practices by ~3 million people in Lucknow city. The Total Hazard Index (THI) exceeded the acceptable limit of unity at all sampling locations in both children and adults across an approximate stretch of 61 km including upstream, midstream, and downstream sites of Lucknow city. The mean value of hazard quotients (HQs) for Cd and Pb were found to be more than unity highlighting the serious health hazard associated with the consumption of river water in both children and adults. The probable sources of HM pollution in River Gomti include direct release of sewage and effluents with or without treatment into the river. The results of non-carcinogenic risk assessment clearly state the higher susceptibility of children to health risks highlighting the urgent need of remedial measures.

**Keywords:** Heavy Metals, Health Risks, River Gomti, Total Hazard Index

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**THEME-X**

**IMPACT OF CLIMATE CHANGE ON WATER RESOURCES**



Paper ID – 016

## Effect of Climate Change on Precipitation for Bhopal, India

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### Abstract

General Circulation Models (GCMs) have been widely used to simulate the current climate and predict future climate change at regional and global scales. GCM CanESM2 have been used to downscale the precipitation for Bhopal city, Madhya Pradesh, India. The SDSM (Statistical downscaling model) is used for downscaling of data. In this study baseline period from 1979-1995 and 1996-2005 is used in calibration and validation respectively. The GCM outputs were evaluated by Nash Sutcliffe Efficiency (NSE) and Coefficient of determination ( $r^2$ ). Future series are generated for RCP 2.6, RCP 4.5, and RCP 8.5 for future period (2006-2035), future period (2036-2070) and future period (2071-2100) using CanESM2 data. Rate of change in precipitation has been compared in three future period for Bhopal city. The study of future simulations shows that there is change in Precipitation for Bhopal city.

**Keywords:** General Circulation Model (GCM); CanESM2; RCP 2.6; RCP 4.5; RCP 8.5.

Paper ID – 048

## A MORPHOLOGICAL COMPARISON OF TWO DIFFERENT CLIMATIC SETTINGS AND ITS SIGNIFICANCE ON THEIR SEDIMENT YIELD

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### Abstract

Several parts of the world have been facing severe droughts and frequent floods due to climatic variables. For efficient management and adaptation measures, it is important to understand the relative effect of climate variability, morphometric variability on runoff, sediment erosion and sediment deposition. In the present study a comprehensive comparison of India's two major river basins, Budhabalanga and Nagavali belongs to two different climate settings is done on the basis of morphometric parameters, Land Use Land Cover (LULC) and soil texture. Budhabalanga river is situated in Odisha's Northern plateau zone have a catchment area of 4840 sq.km. and Nagavali river is of Eastern ghat zone have a catchment area of 9510 sq.km. These two rivers are very prone to flood in every year monsoon. In this study ASTER digital elevation model (DEM) data are used in Geographic Information System (GIS) environment for evaluation of linear, areal and relief aspects of morphological parameters. LULC map of India and soil map of world are used for respective study. To complete the study, runoff and sediment yield data (2010-2016) are collected from Central Water Commission (CWC). Based on the relation of sediment yield volume with these parameters sediment prone areas are identified. This study will be helpful to the concerned people/ departments in prediction of sediment yield, erosion of bank and will be useful in soil and water conservation process and plan strategies for any construction work.

**Key words:** Morphometric analysis, LULC, Soil Classification, Geographic Information System, Sediment yield.



Paper ID – 091

## **Sensitivity change of water deficit droughts on evapotranspiration methods in the Indian subcontinent**

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### **Abstract**

The choice of general circulation model (GCM) and reference evapotranspiration (ET<sub>o</sub>) estimation methods are crucial to projecting water deficit. Standardized Precipitation Evapotranspiration Index (SPEI) which is derived from water deficit also depends on choice of GCM and ET<sub>o</sub> estimation methods. In this study variance-based global sensitivity analysis will be used to evaluate relative sensitivity of projected changes in future water deficit (P-ET<sub>o</sub>) and SPEI to the choice of GCM and ET<sub>o</sub> estimation methods over parts of the Indian subcontinent. Two distinct periods are considered i.e. 2030-2060 and 2070-2100 for analysing the change in water deficit and droughts. To quantify the range and estimate the relative sensitivity of future projections to both factors, 7 GCMs and 11 ET<sub>o</sub> estimation methods are used. The 11 ET<sub>o</sub> methods are categorized into 4 major ET<sub>o</sub> methods based on temperature, radiation, mass transfer and combination. Results show that changes in future water deficit and droughts properties varies with regions and seasons. Overall, changes in water deficit droughts are more influenced by the choice of ET<sub>o</sub>, while GCM effects are more prominent for different regions. Result of this study indicate, the role of proper ensemble formation of GCMs and ET<sub>o</sub> estimation methods based on seasons and regions, to develop a robust range of future conditions for water resources planning.

**Keywords:** *Standardized Precipitation Evapotranspiration Index, Global Sensitivity Analysis, Drought.*

Paper ID – 132

## **Generation of Intensity-Duration-Frequency Curve for a River Basin in South Kerala by Incorporating Climate Changes**

**Lini R. Chandran<sup>1</sup>, Aiswarya B. Babu<sup>2</sup>, Krishna Priya S. B.<sup>3</sup>, Sumina<sup>4</sup>, Sini S. Nair<sup>5</sup>**

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### **Abstract**

Global warming has a significant impact on frequency of extreme precipitation. It is one of the prominent factors which cause huge impact on drainage system by means of flooding. Intensity Duration – Frequency (IDF) curve plays a crucial role in designing robust drainage systems. Over the years it is seen that there is noticeable climate variability in many parts of the country. Hence to resist the impact of extreme precipitation we need to consider climate changes also by incorporating climate variable data in the IDF curve. In this study, IDF curves for the Neyyar river basin in Southern part of Kerala was generated using historical rainfall data from IMD for a period of 1955-2005 using Gumbel's distribution. This area was selected for the study as many major irrigation projects of the state are commissioned here. This IDF curve was compared with the standard IDF curve generated using the empirical relationship developed by Sherman C.W. (1931) and further modified by Bernard M. (1932) and the parameters suggested by Ram Babu (1979) and both the curves were found to follow the same pattern. The IDF curve was also developed for a period of 2006-2050 from the rainfall projected over the period from the multivariate linear regression model developed for each month. The projection of rainfall was performed using the predictor variables derived from the ICTP regional climate model (RegCM4). The NRMSE value of 0.08 obtained between the standard and projected IDF Curves shows that the



curves developed by incorporating climate variables are more reliable than the standard curves for water resources applications.

**Keywords:** *Extreme precipitation, Gumbel's distribution, Multivariate linear regression model, Intensity– Duration-Frequency Curve*

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Paper ID – 152

### **A review on Climate Change Impact Analysis using Statistical tools**

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#### **Abstract**

Science has shown that climate change is impacting every corner of the environment on our planet and the water cycle is no exception. Climate is considered to be the greatest challenge faced by mankind in the present era. It is therefore, very important to study the predictions and analyses of change in critical climate variables such as precipitation and temperature and to strategize parameters about the future management. It will also help to predict the special regions that are vulnerable to climate change which will give the future scenario of water resources. The main aim of this study is to provide a literature review and discuss about the researchers who carried out the study of climate change behaviour. Various techniques and tools have been employed by all the researchers to study rainfall and temperature analysis. Statistical methods are most widely used for this study.

**Keywords:** *Climate change; precipitation and temperature analysis; statistical tools*

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Paper ID – 370

### **Climate Variability Influences on Seasonal Precipitation-Temperature Associations across Florida**

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#### **Abstract**

Climate variability is found to exert varied influences on the meteorological processes across the globe depending upon the geographical location. The exploration of climate variability influences on hydroclimatic variables is key for effective water resources management. The space-time variability of precipitation and temperature is also influenced by large-scale oceanic-atmospheric oscillations, apart from local physiographic factors such as topography and land use. The current study focuses upon an investigation of influences of large-scale oceanic-atmospheric oscillations such as El Niño Southern Oscillation (ENSO) and Atlantic Multidecadal Oscillation (AMO) on seasonal precipitation-temperature (P-T) association for Florida, USA. The dry and wet seasons in Florida extends from November to April and May to October, respectively. The monthly precipitation and temperature data for the period 1950-2017 are analyzed to assess the changes in seasonal P-T correlations within two temporal windows (i.e., 1950-1983 and 1984-2017) using multiple rank-based association measures. The influence of ENSO and AMO phases, viz., El Niño and La Niña, and Warm AMO and Cool AMO, on



variations in the P-T associations, are evaluated for the dry and wet seasons. A nonparametric test, the Mann-Whitney test, is used to evaluate the statistically significant differences in seasonal P-T associations between two temporal windows during ENSO and AMO phases. The results indicated the predominance of wet and hot conditions during the summer, while the prevalence of dry and cool conditions during the winter. Also, considerable variations in P-T associations are observed, wherein a positive shift in the P-T association is noticed in the recent period as compared to the earlier period.

**Keywords:** *Climate variability, El Niño Southern Oscillation, Atlantic Multidecadal Oscillation, Nonparametric tests, Florida*

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Paper ID – 419

## **Assessment of Climate Change for Generating Grid Wise Future Scenarios of Precipitation and Temperature Over Lower Godavari Sub Basin Maharashtra State, India.**

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### **Abstract**

Climate change causes severe effect on human health, agricultural field, water resources sectors etc. Hence assessment of climate change is very important. There are different ways to assess the climate change. One of the way is 'Downscaling'. Downscaling is the way of finding climatic variables at local scale which are available at larger scale. Downscaling has two ways to perform, either by dynamical way or by statistical way. The work on downscaling has been classified into two groups, first one is work on finding different possible ways of downscaling and second one is work in which results of downscaling were used for prediction of effects of climate on different sectors. To perform downscaling in statistical way, we can use SDSM (Statistical Downscaling Model) software. This software predicts future values for climate variables by establishing relation between local scale variables and larger scale variables i.e. variables provided by GCM (General Circulation Models). In the present study, we have used SDSM tool for a statistical downscaling of Temperature (Tmax, Tmin) and Precipitation over lower Godavari Sub basin Maharashtra State India (Latitude:19011', Longitude:76033'). The National Centre for Environmental Prediction (NCEP) reanalysis dataset for the period 1961-2000 and GCM data of HadCM3 under A2a and B2a scenarios have been used. To get better results in downscaling, study has been carried out grid wise. For Temperature downscaling  $0.50^0 \times 0.50^0$  grid resolution data have been used whereas for precipitation  $0.25^0 \times 0.25^0$  grid resolution data have been used. Calibration and validation have been performed for each grid and results have been plotted. Results are plotted in three future series 2020s, 2050s and 2080s. All the variables i.e. Tmax, Tmin and Precipitation show increasing trends under A2a and B2a scenarios. The mean monthly values of these variables are compared. Highest increase have been noted for 2080s series and lowest increase have been recorded for 2020s series.

**Keywords:** *SDSM, HadCM3, A2a, B2a, Tmax, Tmin, Precipitation*

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## Effect of Climate Change on the Precipitation of Saraikela-Kharsawan District of Jharkhand by Statistical Downscaling Method

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### Abstract

Over the years, changing climate has been a matter of concern which has led to drastic changes in various climatic factors like precipitation, temperature, humidity etc. The state of Jharkhand receives a lower amount of precipitation when compared with other states of India. So the objective of the study was to predict the future rainfall of a district receiving moderate to low rainfall. The second generation of the Canadian Earth System Model (CanESM2) was the chosen Global Climatic Model for the study. The historical precipitation data of the district Saraikela-Kharsawan that was used to downscale was chosen from the 15 years span of 1981-1995.

The prediction of the monthly average precipitation was based on two separate Representative Concentration Pathways i.e., RCP4.5 and RCP8.5 with an aim to find out the precipitation from 2021 to 2090 considering whether the emission of greenhouse gas CO<sub>2</sub> will be controlled or will not be controlled in the upcoming years. The study proves that there is an increase of 16.5386% while considering RCP4.5 and a considerable increase of 24.2795% while considering RCP8.5 until the year 2090. By this study, there is a future scope of prediction of river flow, groundwater recharge, sedimentation etc for that particular district of Saraikela-Kharsawan.

**Keywords:** Precipitation, downscale, global climate model, greenhouse, representative concentration pathway

## Ranking of CMIP6 based Global Climate Models for prediction of temperature in Godavari river basin

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### Abstract

Climate change is emerging as one of the crucial problems to our environment as they would lead to negative effects on natural as well as human systems. To examine the climate change impact on a river basin, prediction of future climate is essential. Global Climate Models (GCMs), also known as the General Circulation Models are the most credible tools for modeling the climate change. In the present study, selection of suitable GCM to assess the performance of maximum temperature ( $T_{max}$ ) simulation for Godavari river basin covering 28 points (with a grid resolution of 1° X 1°) is assessed. The observed and model historical temperature datasets cover the period from 2000-2019. Twelve Coupled Model Intercomparison Project – Phase 6 (CMIP6) GCMs (ACCESS-CM2, BCC-CSM2-MR, CanESM5, GISS-E2-1-G, FGOALS-g3, GFDL-ESM4, HadGEM3, IPSL-CM6A, MIROC-ES2L, MPI-ESM1, NESM3, UKESM1) are used for the climate variable ( $T_{max}$ ) using five performance indicators. Performance indicators used are Correlation Coefficient (CC), Skill Score (SS), Absolute Normalized Mean Bias Deviation (ANMBD), Normalized Root Mean Square Deviation (NRMSD), Average Absolute Relative Deviation (AARD). GCMs are downscaled to finer spatial resolution before ranking them. Statistical downscaling technique is applied to eliminate the systematic biases in GCM simulations. Weights are determined using Entropy technique for each performance metric. Preference Ranking Organization Method of



Enrichment Evaluation (PROMETHEE-2) and Compromise programming (CP) methods are utilized to rank the GCMs for the study area. Group decision making is an approach used to integrate the ranking techniques of GCMs to get a collective single rank. The results obtained suggest that MIROC-ES2L, HadGEM3, GFDL-ESM4, ACCESS-CM2 and FGOALS-g3 are the top five models that are suitable for prediction of maximum temperature for the Godavari river basin.

**Keywords:** GCM, CMIP6, Entropy method, PROMETHEE-2, Compromise Programming

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Paper ID – 463

## Climate change or land-use dominated streamflow variations: An empirical model-based contribution analysis of the Baitarani River Basin, India

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### Abstract

Streamflow, which is considered as the fundamental element of the basin-scale hydrological processes, is influenced by climate change (CC) and land-use transformations (LUT). Quantifying the relative impacts of the above drivers on streamflow variation has drawn significant attention from researchers nowadays. In this study, the relative contributions of CC and LUT for the Baitarani River Basin (BRB) of eastern India are estimated using two empirical approaches i.e. (i) the modified Double Mass Curve (DMC) method and (ii) the modified Slope Change Ratio of Accumulative Quantity (SCARQ) method. The statistical characteristics (trend, slope, and significance) of hydro-meteorological variables (precipitation, temperature, and streamflow) are studied for the study period (1979-2018) employing the Mann-Kendall test. The sequential Mann-Kendall test is applied to check the abrupt shift or break in the streamflow data series. Based on the outcomes of abrupt change analysis, the entire study period is divided into the reference period (1979-1994) and the impacted period (1995-2018). The results of the empirical methods showed that the relative impacts of the LUT ( $\lambda_{LUT}$ ) are presiding over CC ( $\lambda_{CC}$ ) on streamflow variations in the impacted period of the study area. Further, the SCARQ method is relatively convenient as compared to the DMC method since it is capable of estimating the relative influences of both the climatic factors i.e. the impact of precipitation ( $\lambda_P$ ) and the impact of temperature ( $\lambda_T$ ) on the streamflow variations. However, both the empirical methods are attributed to different sources of errors and uncertainty with individual advantages. Thus, the outcomes of this study can provide vital information regarding the relative vulnerability of the BRB streamflow to CC and LUT that is essential for the sustainable planning and management of future water resources.

**Keywords:** Climate change; Land-use transformations; DMC method; SCARQ method

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**THEME - XI**  
**RIVER HYDRAULICS**



## Flow Resistance in an Open Channel Flow

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### Abstract

The problem of predicting flow resistance in the rough bed channels with satisfactory performance is of excessive attention to hydraulic engineers. For a prismatic channel or a non-prismatic channel, one of the important aspects is the bed resistance acting in the channel. The formulas developed in recent year, are empirically or graphically derived on the basis of one-dimensional analysis. In this work, a series of experiments were conducted in a large tilting flume to investigate the flow resistance in a rough bed channel. Based on the observed data, an empirical equation for the flow resistance is proposed. The benefit of propose equation is that it establishes relation between flow resistance, Shear Reynolds Number and Froude Number. The flow resistance is indirectly proportional to the Shear Reynolds Number and Froude Number. Based on the various efficient criterions, the developed model predicts well the flow resistance in the rough bed channel. Also, the proposed model is compared with the previous literature through various parameters like Mean Squared Error, Nash-Sutcliffe efficiency, Index of Agreement, etc.

**Keywords:** Flow Resistance; Shear Reynolds Number; Froude Number.

## Effect of Dense Streambank Vegetation with Steep Sloping Riverbanks on Manning's Roughness Coefficient of 0.11 in Hydraulic Model Studies

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### Abstract

The Manning's Roughness Coefficient ( $n$ ) is a major hydraulic parameter which extensively affects the estimation of velocities and consequently the water surface elevations along any water conductor system. The assessment of  $n$  value involves many uncertainties, as its estimation is based on literature, judgement and most importantly the slope of the water conductor system. Project reach is characterized with the highly vegetated steep sloping banks of the river. The riverbanks are mainly rainforests, densely vegetated with high trees and bushes. Riverbed is consisting of gravels, rocks and large boulders. The river slope is around 1 in 100 at the river reach under consideration. The daunting task as per the contract was to calibrate the hydraulic model of the river by reproducing the ' $n$ ' value of 0.11 (Prototype) for riverbank rainforests. Various alternatives were carried out to match these high friction values in the 3D comprehensive hydraulic as well as 2D mathematical model. The ' $n$ ' value in hydraulic model was then arrived based on the results of calibration. It was observed that, these high friction values do not affect much on the composite Manning's ' $n$ ' value of the river reach, especially due to the steep slope of the river. This paper represents the results of these studies and recommendations for steep river flows.

**Keywords -** Manning's roughness, streambank vegetation, River model calibration, steep sloping rivers



Paper ID –72

## Sediment modelling and trend analysis for Ungauged sub watersheds in Western Ghats

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### Abstract

It becomes necessary to install sediment observatory station for monitoring sediment yield within the watershed but due to economical priority and difficulty in accessibility of gauges due to severe silting at sites. There is need of numerical or empirical models to estimate probable sediment yield in a catchment. Thus, (MUSLE) Modified universal soil loss equation, an empirical model is used which take into account of basin runoff and peak discharge as major dataset to estimate sediment loss from watershed. For this study HEC HMS (Hydrological engineering centre Hydrological modelling system) tool is used to estimate annual runoff and peak discharge from continuous simulation model. The result shows, this sediment model is mainly dependent on three factors namely Land use, Soil and slope of topography where, Land use being the dominating factor for sediment deposit followed by soil and slope. It can be analysed from graphs that there is direct relationship between sediment yield v/s runoff, rather than the sediment yield v/s rainfall. This model also shows that sub watersheds which are more of agriculture land use has greater sediment deposit compared to that of urban and evergreen forest land use. By trend analysis greater the runoff higher is the sediment mark, reduction factor being the vegetation index and slope characteristics of individual sub watersheds in smaller magnitude for area under study.

**Keywords:** MUSLE, Sediment yield, Trend analysis and continuous model

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Paper ID –87

## Discharge predictions of meandering river using artificial neural networks

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### Abstract

For streams the most important parameter is the discharge. It is essential to establish rating curve well in advance. But the discharge prediction problem lies for meandering rivers where the influence of the curved geometry (due to erosion/deposition) is highly pronounced, may lead to flood problem on its banks, e.g. Barak river. ANN model was used to address this problem. Sinuosity values were extracted from remote sensing tool. Knowing the monthly head and discharge values of past 13 years, it would predict the future values of discharge for this river. Four parameters as input variables viz. head, slope, sinuosity of the current month as well as the previous month's discharge, one output variables i.e. current month's discharge was considered. The impact of learning rate of the developed ANN model was examined on the basis of performance indices like RMSE, coefficient of correlation, coefficient of determination. In the present study, the ANN model was developed using data sets of Barak river (Annapurna Ghat gauging site). It can be useful for better planning of flood warning system.

**Keywords:** Discharge prediction; ANN; sinuosity; remote sensing

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## Investigation of the Issues in the Inter Linking of Rivers: A Case Study for Godavari-Krishna Link Indira Sagar Polavaram Project

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### Abstract

Government is working on the basic principle of interlinking of people by collecting tax from people in order to provide products and services to the peoples and thereby to create synchronous and harmonious living environment with the characteristics of Concrete Society rather than Aggregate Society. Accordingly, in the name of Interlinking of Rivers, collecting water from some rivers and transferring water to other rivers becomes the basic Characteristics of a Government in order to balance Flood and Drought across the time and space domains of the nation and thereby to convert the existing Aggregate Basins into a Concrete Basin having high Resilience to the impact of Climate Change and that of Population Growth. Anyhow the observation in the last two decades shows the existence of a lot of issues against the implementation of National River Linking Projects (NRLP) of India designed based on the principle of Inter Basin Water Transfer (IBWT). This article focuses on the investigation of various specific issues including that of flora and fauna existing over one of the Peninsular Components of the NRLP of India named as Godavari-Krishna Link Indira Sagar Polavaram Project having the idea conceived during the British Colonial Period by 1941. In addition, various general issues existing over the interlinking of rivers using NRLP of India have been presented. Various quantitative benefits motivating towards successful implementation of this Project have also been explored. The Hydraulic and Hydrologic characteristics of this project including flood handling capacity have been analyzed. The flood submergence characteristics of the Godavari River with and without this project have been compared for both the cases of upstream and downstream sides of the Polavaram Dam.

**Keywords:** Concrete Basin versus Aggregate Basins; NRLP of India; Issues and Benefits of IBWT; Hydraulic & Hydrologic Characteristics; Godavari-Krishna Link Indira Sagar Polavaram Project;

## Applicability of Variable Parameter McCarthy-Muskingum (VPMM) Model for Reverse Flow Routing

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### Abstract

For hydrological applications, the stage and discharge information at any river section are sparsely available in most of the world-rivers, and they are still ill-equipped in terms of hydrologic monitoring. Sometimes in a catchment, the downstream flow information is available with little or no knowledge of the upstream flow, which are generally essential for preparing flood management strategies in the catchment along with appropriate reservoir operation during flooding. In this regard, reverse flow routing can be used to transfer flow information at a downstream gauging station to an upstream un-gauged station. However, this problem is ill-posed and is



sensitive to perturbations in the data to be inverted, resulting in the amplification of errors. Therefore, this study advocates the physically-based simplified Variable Parameter McCarthy-Muskingum (VPMM) model for flow reversal to get information at the required upstream station, which has potential field uses. In a numerical study, a hypothetical inflow hydrograph in the form of Pearson type-III distribution was routed downstream in a hypothetical prismatic reach of 30 km length using the HEC-RAS 5.0.3 (benchmark) model. The channel characteristics are comprised of different types of channel cross-section and Manning's roughness conditions. Considering the HEC-RAS 5.0.3 simulated downstream hydrographs as the observed information, they were reverse routed using the VPMM model to obtain the corresponding upstream inflow hydrographs. The results showed the VPMM model's potential to simulate the observed inflow hydrographs, especially in reproducing the peak flows well. However, there is a poor reproduction of the low flows.

**Key Words:** VPMM; HEC-RAS; Reverse flow routing; Hypothetical reach

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Paper ID –126

### **Application of Three Models for Estimating Daily Streamflow Simulation in Pulichinthala Sub-basin**

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#### **Abstract**

This paper contrasts the relative contribution of state observations and perfect data generation for sequence of water supply, improving multipurpose water reservoirs operation over short-term and long-term temporal scales. The main aim to generate streamflow data for calculating reservoir capacities with precipitation, temperature and evaporation data (2014-2017 & 2018) in Dr. K. L. Rao Pulichintala Project Sub-Basin (KLRSP). From that, Planning and operation decisions need to be made at different times depending on the requirements of the project. The KLRSP sub-basin moderately falls under a semi-arid zone, around a central arid zone with major soil types being black soils, alluvium, red and mixed soils. KLRSP sub-basin employing ANN, SWAT and MLR models. Finally, out of three models, SWAT and ANN models reveals better performance rather than MLR model in simulation and prediction of KLRSP sub-basin, the uncertainty of the parameters was assessed with R<sup>2</sup>, NSE, RMSE and PBIAS. The results of calibration period (R<sup>2</sup>=0.97, NSE=0.97, RMSE=9.4 and PBIAS=5.4) confirmed the potential of SUFI-2 algorithm for simulating streamflow data. The ANN model (training, validation and test data) results for calibration (R<sup>2</sup>=0.9, NSE=0.75, RMSE=10.78 and PBIAS=22.30) for KLRSP sub-basin correspond comparatively well than the MLR model at lower data points.

**Keywords:** SWAT, Regression, Reservoir, Simulation, Pulichintala Project

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Paper ID –143

## **MEMS (Micro-electromechanical Systems) Based Remote Operated Bed Profiler for River Model**

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### **Abstract**

The Micro-Electromechanical Systems (MEMS)based Remote Operated Bed Profiler for River Model helps in illustrating river bed by collecting the sensor data and transmitting it through a wireless transmission technique. The wireless transmission protocol RF used in the project provides a sufficient range. This range can be varied using an antenna. This makes the model unique and easy to use. The 3-axis MEMS sensor is used to measure the acceleration and rotation which then helps to get details about the river bed. The MEMS accelerometer and gyroscope are used to get the acceleration and rotation of the bot where it is mounted. It uses I2C/SPI communication in order to communicate to Arduino. By using the angle tilt of the particular axis towards the surface, we can convert this angle measurement into height (distance) in Arduino. The sensed data in arduino is then send to the remote location using an RF transmitter. The received data at the remote location is then saved in the form of a “.csv” file. Also, a Graphical User Interface is used to get pictorial view of the data. So, using the MEMS technology we were able to get the 3-dimensional motions of the river field and different plots associated with it.

**Keywords:** Bed Profiler, MEMs, RF Transmission, Contour, Bot, GUI.

Paper ID –151

## **Sensitivity analysis of flood routing parameters in the Nethravathi river basin**

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### **Abstract**

In river and streams, roughness coefficient, flow velocity, river bed materials, bed slope, flowpath varies from place to place. These factors influence the erosion and sedimentation of riverbed particles in the flow regime. Consequently, the river stage and discharge along the cross-section of flow are disturbed resulting in the flooding of river banks and inundation of low-lying areas. In the present study, a sensitivity analysis of flood routing parameters was carried out using a 1-dimensional HEC-RAS model developed for the Nethravathi river regime. The geometrical parameters such as Manning's roughness coefficient, bed slope and computational parameters such as time step and  $\theta$ -weighting parameter were considered to test the model sensitivity. The model was analysed by varying the Manning's roughness and bed slope values with  $\pm 10\%$ ,  $\pm 20\%$  and  $\pm 30\%$  as well as varying the  $\theta$ -weighting parameter from 0.6 to 1, for the computational time step 10 sec, 30 secs, 2 min, 6 min, 15 min and 30 min. The model was found to be very sensitive for the choice of Manning's n values than the consideration of time step,  $\theta$ -parameter and normal depth. However, the normal depth was found to be comparatively sensitive to the model accuracy with river-stage output result rather than the discharge. The study



suggested that the roughness coefficient can overshadow the uncertainties related to insufficient geometry data and the numerical solution.

**Keywords:** Sensitivity analysis; flood routing; HEC-RAS; Manning's roughness co-efficient.

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Paper ID –157

## Safety Analysis of Alluvial Riverbanks

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### Abstract

The alluvial riverbanks of the mighty river Brahmaputra and its tributaries in North East India are mostly unsafe due to steep slopes. Therefore, a safety analysis is carried out in upper Assam by analyzing the bank material characteristics based on the stability of these banks using Culman type stability analysis method. Collected bank materials (soil samples) are tested to determine the unit weights and shear parameters for each bank material. The failure plane angles are determined for each bank for bank angles 60° to 85°. The banks are found to fail at critical bank angles that are calculated for factor of safety 1.00. The safety of these riverbanks is investigated by calculating the stable bank angles for each bank at factor of safety 1.25.

**Keywords:** Alluvial riverbank; Failure Plane Angle.

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Paper ID –199

## Turbulent structures under unsteady flow conditions through emergent rigid vegetation

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### Abstract

The present study investigates the vertical and lateral fluctuating velocity profiles under unsteady flow condition in a rectangular open channel through emergent rigid vegetation. Experiments are conducted with emergent vegetated open channel flow. One identical hydrograph is passed through the rectangular flume with a fixed bottom with rough bed. Hydrograph consists of a starting period  $T_i$  at base flow  $Q_b$ , an ascending limb with duration  $T_s$  starting at base flow  $Q_b$  and ending at peak flow  $Q_p$ , a descending limb with duration  $T_s$  ending at the same base flow  $Q_b$  and outlet period  $T_u$  at base flow  $Q_b$ . The same hydrograph is repeated 198 times so as to measure point velocities at different positions and for different flow depths. Using micro-Preston tube (outer diameter 4.77mm) and Acoustic Doppler Velocimeter (micro ADV), the flow patterns are investigated at both lateral and longitudinal positions over different cross-sections. For two typical flow depths, the velocities in both the rising limb and falling limb are observed. Hysteresis effect between stage-discharge



(h ~ Q) rating curve between rising and falling limbs is illustrated. Lateral distribution of fluctuating velocity and Reynolds stresses are plotted at three different cross sections. Substantial differences between these profiles for the same flow depth in rising and falling cases are observed. The variations of these two turbulent characteristics along the three given sections have been demonstrated.

**Keywords:** *Open channel flow; unsteady flow; hydrograph; fluctuating velocity; Reynolds's stress; turbulence characteristics*

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Paper ID –226

## **Experimental and numerical study of flow around submerged vertical circular cylinder in steady current**

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### **Abstract**

The present study reports the analysis of measurements of three-dimensional flow characteristics around submerged vertical circular cylinders of different diameters using Acoustic Doppler Velocimeter (ADV). The flow field was also numerically simulated and validated with the measurements. Numerical simulations were performed using COMSOL Multiphysics 5.0 with  $k-\omega$  turbulence closure model. Reynolds Averaged Navier-Stokes equation (RANS) with constant turbulence viscosity were considered to solve the numerical model. The normalized turbulent intensity, kinetic energy and vorticity around submerged vertical cylinders over the plane bed were computed from the measured velocity data. The flow fields are represented by the velocity vector plots as well as the vertical distributions around cylinders. The numerically simulated velocity distributions match well with the measurements. The vector diagram shows strong vortex formation close to the cylinder and near the bed, which increases for larger diameter cylinder. Flow concentration towards the top of the submerged cylinder is evident indicating accelerated flow. All the components of the turbulent intensity are higher for higher diameter. The non-dimensional turbulent kinetic energy increases with the decrease of cylinder diameter. The kinetic energy becomes very strong close to the cylinders and near the bed. The vorticity contours also show the formation of horseshoe vortex at the upstream and reverse flow at the downstream of the submerged cylinder. The strength of vorticity increases at the downstream with the increase of cylinder diameter.

**Keywords:** *submerged circular cylinders; flow field; numerical simulation; vorticity; sediment.*

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Paper ID –286

## **Hydrodynamic Modelling of Middle Tapi River Using MIKE 11**

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### **Abstract**

The severe losses of property and lives are observed every year due to flooding conditions across the globe. The events of flood are invariably being considered as natural phenomenon, however, anthropogenic



activities in the catchment and flood plains affect the severity of the events. The prediction of stage-discharge hydrograph in the river is required for effective flood management for adopting various structural and non-structural measures. The present study addresses the development of one-dimensional (1-D) Hydrodynamic model using MIKE 11 software to simulate hydraulic characteristics of flow for Middle Tapi River. The calibration of the unsteady simulation model was performed for the flood events of the years 1998, 1999, 2002, 2003, 2004 and 2005 with the due consideration of upstream and downstream boundary conditions to estimate the optimum value of the Manning's roughness coefficient of the river bed. The upstream and downstream boundary conditions in the calibrated model was taken as flood hydrograph and water levels, respectively. The performance of the calibrated model was determined by comparing the simulated and observed water levels at the intermediate stream gauging stations. With the help of standard performance indices such as Root Mean Square Error (RMSE), Nash-Sutcliffe efficiency (NSE) and Coefficient of Determination ( $R^2$ ). The calibrated model was also validated using the independent flood events of the years 2006 and 2007. The performance of developed model during validation period was found to be satisfactory, with RMSE and NSE of 0.975 m and 0.966 m, 0.980 and 0.861, respectively.

**Keywords:** Hydrodynamic modelling, MIKE 11, Middle Tapi River, Manning's roughness coefficient.

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Paper ID –293

## Simulation of Channel Bed Level Variation and Its Experimental Validation

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### Abstract

Aggradation and degradation in the alluvial channels are natural phenomena formed mainly near the structures such as bridge piers, abutments, etc. in the river. A study on aggradation and degradation is required to prevent damage to these structures. Experiments were conducted in the laboratory flume with sediment overloading to study the bed and water level variations of uniform sediments under uniform flow condition by Soni et al. (1980), Rehman et al. (2010) and Andharia et al. (2018). In the present study, a one-dimensional semi coupled Hydrodynamic model with Sediment transport module was developed in MIKE 11 using the data from the above three study. The bed level and water level variations were computed using Meyer Peter Muller (MPM) sediment transport function in the aforesaid model. The model developed was used to predict the transient bed and water levels corresponding to 15, 30 and 40-minutes time intervals for the test run U-1 (Soni et al. 1980) and also for 15, 30, 60 and 120-minutes time intervals corresponding to the test run A-1 (Andharia et al. 2018). The transient bed levels corresponding to 1, 2, 3 and 4-hour time intervals from the beginning of sediment overloading for the test run -1 (Rehman et al. 2010) was also predicted using the model. The comparison between simulated and experimental results of bed and water level variation was evaluated and found satisfactory.

**Keywords:** Aggradation; Degradation; Sediment Overloading; Hydrodynamic Model; Sediment Transport Module; MIKE 11



Paper ID –298

## Water security assessment of Karuvannur watershed - Current and future scenario

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### Abstract

Water security is referred as the availability of sufficient amount of water of good quality to boost all ecosystem services with a tolerable level of water related risks, whereas water scarcity is defined as the ratio of water demand over water availability and it is used as an indicator of water security (Giri et al. 2018). The water security in a watershed may get adversely affected due to the changes in climate and land use pattern, population growth, developmental activities etc. Since the balance between water demand and water availability has reached life-threatening levels in many regions, the gravity of water security issue can be gauged by compartmentalizing various kinds of water demands and available sources. Hence the present and future water security assessment based on the classification of the available water into blue and green water is done in this paper, since it gives a clear picture about the effects of human intervention on freshwater resources. Future land use and climate are predicted using CLUE-S and SDSM 4.2.9 models respectively and the crop water requirement is assessed using CROPWAT. The different components of blue and green water are calculated by modeling the watershed in Arc SWAT and water security is assessed separately under present and future condition. It is observed that water security diminishes at an alarming rate due to climatic and land use changes. The severity of the problem is even more in the case of green water as increased demand for water in food production is expected in the future.

**Keywords:** Water security; CLUE-S; SDSM; Arc SWAT; CROPWAT

Paper ID –307

## Evaluating Periodic Changes of River Discharge Carrying Capacity: A Case Study of Lower Tapi River

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### Abstract

The dynamic equilibrium of natural rivers is getting altered significantly due to natural or human induced activities along the rivers, viz. excessive inflow of sediments from the catchments in the form of land slide, construction of hydraulic structures like storage dams and weirs or barrages, sand mining activities on the river bed and encroachment of flood plains. Ever since the construction of Ukai dam across Tapi river in the year 1972, the flow characteristics in the downstream of the river got altered, thereby, impacting the carrying capacity of the river. The coastal flood plain of Surat city has witnessed six major flood events after the construction of Ukai dam. The periodic changes of carrying capacity of Tapi river was evaluated by considering the discharge at Ghala stream gauging station (located at 37 km upstream of Surat city and at 65 km downstream of Ukai dam) and water levels at the Nehru bridge in the Surat city over a period of 1978–1994. It is noticed that, for warning level (+8.5m) at Nehru bridge, the carrying capacity was estimated to be 5.15, 4.91, 5.08 and 4.15 lacs cusecs during the period 1978 – 88, 1980 – 90, 1982 – 92 and 1984 – 94 respectively. The carrying capacity of Tapi river in Surat city was estimated to be approximately 8.5 lacs cusecs at the time of dam construction. From aforesaid values, it can be inferred that, after the construction of Ukai dam, the river carrying capacity got reduced to less than half by 1994. The possible reason for such drastic capacity reduction could be



due to, morphological changes in the Tapi river, inadequate discharge in the river to flush the sediments deposited during tidal currents and encroachments in the river floodplains.

**Keywords:** Tapi river, Carrying capacity; Ukai dam; Surat city; Capacity curves.

Paper ID –334

## **Analysing kinetic energy and momentum coefficients in a meandering channel with and without vegetated flood plains**

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### **Abstract**

In this present paper an effort has been made to calculate the kinetic energy and momentum coefficients in a meandering vegetated flood plain channel. Effective analysis of the hydraulic parameters in natural channels with rough vegetated flood plains are necessary for accurate prediction of stage discharge curves, velocity profiles, critical depths, energy losses and also for effective flood management. Any error in the kinetic energy and momentum coefficients may lead to noticeable error in the prediction of the above-mentioned parameters. This variation is more in meandering compound channel compared with the simple straight channel. Present experiments were carried out in a meandering compound channel with and without rigid vegetated flood plains at the 30 degrees' bend. The variation of kinetic and momentum correction factors in a meandering compound channel with and without rigid vegetated flood plains are compared at apex and crossover positions.

**Keywords:** Meandering Compound channel flow; kinetic energy coefficient; momentum correction; rigid vegetated floodplain; velocity distribution, regression analysis.

Paper ID –335

## **Flow Modelling and Evaluating Impact of Roughness on Turbulent Flow Properties in Diverging Channel**

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### **Abstract**

During Floods or when a river joins a reservoir, it expands over the area and flow velocity is reduced. Due to effects of gravity, momentum and local scouring and other natural causes river over flow on its flood plain and keep expanding and behaves as non-prismatic diverging compound channel. In natural river systems, flood plains are rougher than main channel. Then flow on flood plain interacts with main channel. This 'Kinetics effect' causes formation of secondary currents. This momentum transfer between main channel and flood plain is effected by roughness of channel. So present study aims to find how roughness affects distribution of longitudinal velocity in diverging compound channel with non-homogeneous roughness and homogeneous roughness. In Non- homogeneous roughness condition, Concrete channel with gravel on flood plains case is considered. In homogeneous roughness case, smooth Cement concreted channel is considered. In this study, diverging channel with diverging angle of 9.83 and relative depth 0.334. Flow modelling is done by using ANSYS software. Present study compares results of depth averaged velocity, turbulent kinetic energy, Boundary shear stresses of both homogeneous and non- homogeneous roughness cases. Boundary shear stress computed using TKE method and ANSYS are compared and concluded that TKE method can be used for non-prismatic channels but for highly roughened beds. Gravel bed is assumed as stationary; no bed load transport is allowed.



**Keywords:** Flow modelling, Depth averaged velocity, Boundary shear stress, ANSYS, Gravel bed, TKE

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Paper ID –339

## STUDY OF UNSTEADY FLOW PARAMETERS AND HYSTERESIS EFFECT IN A SIMPLE CHANNEL UNDER UNSTEADY FLOW CONDITION

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### Abstract

Flows in the natural rivers and channels are often unsteady. Rivers in flood are characterized by unsteadiness of the flow. Various field studies show that when flood passes in a river, the bed load movement, the suspended-load distributions, as well as the river processes are different from those in steady flow. Therefore, it is very important to understand the behavior of unsteady open channel flow and to predict the flood passage and the river processes. Some researchers proposed some parameters called unsteady flow parameters to understand the behavior of unsteady flow. However, there are very less literatures available on the study of unsteady flow parameters. In this present study, experimentations on a simple open channel is performed under unsteady flow condition to investigate the various parameters of unsteady flow. Two hydrographs are passed through the rectangular flume with a fixed rigid grass bed under two different inlet conditions. Flow hydrograph and depth hydrographs are plotted for both the different inlet conditions. The hysteresis effect of stage-discharge ( $h \sim Q$ ) rating curve between rising and falling limbs is also studied for the present hydrographs. To study more about the hysteresis effect in unsteady flow another data sets of Bombar (2016) has been considered and stage-velocity curves are presented. In the present study, three unsteady flow parameters have been considered. A total of nine hydrographs were studied including the present hydrographs and data of other researchers. It has been observed that the rising and falling limbs in hysteresis plots are closer to each other in experiments having low unsteadiness whereas the limbs are more separated in experiments having high unsteadiness.

**Key Words:** Unsteady Flow, Simple Channel, Hydrograph, Unsteady Flow Parameter, Hysteresis effect.

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Paper ID –423

## Variation of Sediment Transport in Godavari Basin, India

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### Abstract

This is a brief report about the study of sediment transport which occurs in the rivers especially during high flow rates in the river and which leads to various losses like decreasing the capacity of flow in the canal, reducing the useful life of a reservoir or dam and so on. A brief description about the types of sediment load in the river, the factors affecting the sediment transportation is discussed. The methodology mentioning the various approaches or equations to calculate the bed load in the river based on different concepts is discussed here, also suspended load is obtained from the website India – WRIS and adding them both will yield the total load. The Godavari basin which has majority of its land area in Maharashtra is considered as the study area for the dissertation and the data required for the computation of bed load, like the Velocity of flow, the Discharge, slope, Manning's n, Mean Hydraulic Radius, etc. are obtained from the Central Water Commission (CWC). After computing the bed load from the above approach, the modelling of the results obtained is done using

Microsoft Excel. The model prepared is then validated using three different performance indices namely the Coefficient of Determination ( $R^2$ ), Root Mean Square Error (RMSE) and the Nash – Sutcliffe Efficiency (NSE).

**Keywords:** sediment transport, capacity, approaches, bed load, suspended load, total load

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**THEME – XII**  
**RIVER AND COASTAL ENGINEERING**



Paper ID - 006

## FLOOD ESTIMATION BASED ON WATER SURFACE VELOCITY USING NON-CONTACT SENSING AND REGRESSION ANALYSIS

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### Abstract

Flood is the flow which is not handled within the riverbanks. This is normally caused due to excess discharge due to release of water from dam arising due to heavy downpour in upstream catchments within short span of time. These conditions are most destructive and highly complex in nature. The Flood estimation models contributed to reduction of risk, minimization of loss of human life, and reduction of the property damage associated with Flood. However, measurement of such events is challenging. In this paper, the flood is estimated by image analysis methods applied to estimate the discharge in river stream with improved accuracy within a fraction of time. The estimation of flood is analyzed with 'Logistic Regression' using a machine learning algorithm and compared with existing state-of-art methods. This is then used to train and test the model. The results shown in the paper are calculated on the Khakassia canal and Murtha River in Pune region. Video Processing is proposed to extract the displacement of the object in water from the frames of the video captured by a camera. Based on the cross-section of the river which is taken in Literature Survey using Distance Sensor the Area of the river is calculated. The discharge is then eventually estimated. A data logger is made to estimate the discharge based on the surface velocity and the cross-section profile extracted from literature as well as measured before the flooding instances. For the estimation of flood "Logistic Regression" algorithm is used. This algorithm is one of the most used machine learning (ML) algorithms for Binary classification. The model is first trained and then tested using 3:1 ratio. 75% of the dataset is used for Training the model and 25% of the dataset is used for testing the model. The detailed analysis of the performance of the proposed algorithm is analyzed and accuracy is estimated. The trained model is then used to plot a graph to show Flood and non-Flood conditions.

**Keywords:** Flood, Discharge, video Processing, Data Logger, Machine Learning, Logistic Regression, Test-Train model.

Paper ID - 025

## Hydraulic physical model studies for the development of Coast Guard jetty at New Mangalore port, Panambur, Karnataka - a case study

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### Abstract

Physical model studies were carried out at CWPRS for the proposed development of Coast Guard jetty at New Mangalore Port. The initial proposed location of the jetty was on the return of berth No. 18 in Western dock arm (Alt - 1). The said location is adjacent to the harbour entrance. The Coast Guard ships which are to be berthed are small draft vessels. As the proposed place is very near to the harbour entrance, the ship generated waves attack on the broader side of the berthed Coast Guard vessel. The waves entering through



harbour opening also make disturbance to the berthed Coast Guard vessels. Hydraulic physical model studies were conducted in a 3-D rigid bed, multi-directional random wave model for wave tranquility and approaching direction of wave. Since the proposed Coast Guard jetty is to be operative for all round the year, model studies were conducted by generating waves from three critical directions viz. West, South- West, and North-West which are prevalent for different reasons for this port. Wave tranquility studies were conducted by random waves by generating Scott spectra with  $H_s=2.5\text{m}$ ,  $T_z=10\text{sec}$ . Wave approaching direction at the proposed jetty was observed by conducting experiments with regular waves of  $H=2.5\text{m}$  and  $T=10\text{sec}$ . Studies were also conducted for a separate harbour (Alt- 2) exclusively for Coast Guard vessels on North of North breakwater. Taking the shelter of existing North breakwater, the Alt-2 harbour comprises of two breakwaters - outer breakwater and inner breakwater with a dredged depth of -8m in harbour area. The wave tranquility results for both the alternatives and sketches of separate harbour are presented.

**Keywords:** Coast Guard jetty, wave tranquillity, wave direction, jetty alignment, breakwater.

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Paper ID - 167

## SUITABILITY OF REGULAR AND RANDOM SEA WAVE GENERATORS IN HYDRAULIC PHYSICAL MODEL STUDIES - KEY FACTORS FOR SELECTION

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### Abstract

Hydraulic models either physical or mathematical are commonly used modeling tools in coastal engineering. Physical models are having advantages such as – they allow complex geometries, bed topography to be modeled and their visual nature draws attention to small scale flow features. These models are very useful to model complex wave hydrodynamics near shallow water regions for the analysis and design of the harbor and other structures near shore. Hydraulic model studies in basic and applied investigations of wave induced phenomena are conducted on regular wave or random sea wave (wave spectrum) generating physical model. Earlier days physical model studies for coastal engineering investigations are exclusively conducted with regular waves. Whereas in actual sea waves are random in nature. With advancement in the hydraulic modeling technique, it is possible to simulate the wave spectra with close approximation to natural conditions by advanced instrumentation and automation techniques. Having random wave generating facility on a model, it is also possible to generate regular waves also by giving suitable input data. This paper presents the comparative analysis of the results of regular wave and random sea wave generators and their suitability in hydraulic model studies for coastal engineering project development studies. The results of the Regular and Random waves on various physical model studies conducted at CWPRS are presented in this paper highlighting the pros and cons. The suggestive measures for type of wave generator in physical model studies depending on study needs are presented.

**Keywords:** Hydraulic physical models, regular wave, random sea wave, wave generation and wave hydrodynamics.

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Paper ID – 174

### **Assessment of Littoral Drift and Shoreline Changes for a Fishery Harbour on South West Coast of India**

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#### **Abstract**

Development of marine fisheries infrastructure has gained considerable importance in recent years. To cater the demand of national and international markets, many fishery harbour and fish landing Centre are being planned. However, this results in obstruction to natural course of sediment along the shoreline. If due consideration is not given during construction of hydraulic structures, it may cause severe siltation on one side of structure and erosion on the other side resulting in failure to coastal structures and huge economic losses. Thus, it is an essential requirement to carry out scientific studies to assess possible impact of the proposed structures of fishing harbour before undertaking any such project implementation in the field. In the present paper, an assessment of littoral drift distribution and shoreline changes has been made for the proposed open sea fishing harbour located at Thrikkunnappuzha in Kerala on the south west coast of India.

**Keywords:** littoral drift; shoreline change; breakwater; fishery harbour; siltation

Paper ID – 175

### **Assessment of wave tranquillity and littoral drift studies using time dependent wave parameters to develop tourist harbour in Andhra Pradesh**

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#### **Abstract**

Government of India envisages modernization of ports and development of coastlines to contribute India's growth under Sagarmala project. As a part of Sagarmala project developing small tourist harbour at Kakinada along the East coast of India. To check the feasibility of passenger jetty comprehensive studies of wave transformation and tranquillity, assessment of littoral drift and Sedimentation are essential. The paper explains the assessment of wave tranquillity and littoral drift studies using wave time series. MIKE 21-SW model was used for wave transformation studies with 69x70 km area. To estimate littoral movement along the coast it is necessary to have measured wave data. The measured wave data at Kakinada is not available. The yearly wave data from IMD offshore of Andhra Pradesh coast were analyzed and a time series of one-year duration (2012 – 13) with wave height, wave period and wave direction were obtained. The wave time series obtained from IMD data was used as input for the wave transformation studies carried out using MIKE 21 SW model. At the two locations north of Kakinada bay and south of the bay both at -8m depth wave time series were derived from the results of the simulation of one-year duration. These time series of wave parameters were used for the littoral drift studies using LITPACK model. The wave data incorporated the temporal variations of the wave parameters nearshore hence the results are more realistic. The details of the method of the study and the results obtained shall be presented in the paper.

**Keywords:** Wave transformation, lit drift, time series, harbour



Paper ID – 176

## Numerical model studies for assessment of wave tranquillity and littoral drift for proposed passenger jetty in an inlet harbour at Kalingapatnam

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### Abstract

As part of the Central government's Sagarmala project, 36 projects have been proposed by the Andhra Pradesh government. In line with the above, Andhra Pradesh Tourism Development Corporation (APTDC) identified 39 beaches for developmental activities for promotion of tourism. Government of Andhra Pradesh has identified the Kalingapatnam as potential site for the development of a water transport facilities, catering to the needs of transport of material as well as passenger transport for commuters as well as tourist visiting the region. Kalingapatnam Beach is the place where river Vamsadhara empties into Bay of Bengal, it has one of the major beach sand deposits of the state. The present paper discusses the details of the Numerical model studies carried out by different module of MIKE21 software to assess the wave tranquillity and littoral drift for the proposed development in an inlet harbour at Kalingapatnam, to establish the feasibility from the hydraulics point of view. The proposed development consists of approach channel of width of 100 m, depth 5 m, turning circle of 200 m diameter dredged to -5.5 m, along with the northern and southern sand traps of -5.5 m depth, adjacent to the channel on the shore. The wave transformation studies carried out to obtain input wave conditions for wave tranquillity studies and nearshore wave climate for littoral drift studies. Further details of the study shall be presented in the full-length paper.

**Keywords:** Numerical Model, Wave Tranquillity, Littoral Drift, Inlet Harbour.

Paper ID – 177

## Wave Hindcasting and Storm Surge Analysis at Porbandar, Gujarat

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### Abstract

Storm surge can cause colossal damage to life, property and coastal infrastructure. Stability of coastal infrastructure depends on structural design that should withstand extreme wave conditions without significant damage. Determination of design wave height should be based on the statistical analysis of long-term extreme wave height measurements. Since the long-term measurements of extreme wave heights which occur during the storm conditions are not often available, the extreme value analysis is carried out using hindcast storm wave data for estimating the design wave conditions. This paper describes the numerical model studies carried out for estimation of extreme wave, surge and water level conditions during the cyclonic climate at the coast of Porbandar. Information of past 60 years of cyclones (1959-2019) was collected from the Indian Metrological Department and used for present wave hindcasting studies. A 100-year return-period wave height of 7.87 m was predicted at the Porbandar, from extreme value analysis of hindcast storm wave data. The storm surge analysis revealed that storm surge of 2.14 m may occur for return period of 1 in 100 years for Porbandar. The Water



level data fitted in distribution functions to predict its value for different return period reveal that the water level of 6.05 m may occur for return period of 1 in 100 years for Porbandar.

**Keywords:** Hindcasting; Storm; Extreme Value Analysis

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Paper ID – 178

### **IMPORTANCE OF OPTIMIZATION OF OVER LAPPING OF BREAKWATER AT FISHING HARBOUR ENTRANCE**

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#### **Abstract**

Adequate wave tranquility at the berthing area and at entrance is an essential requirement for development of a fishing harbour. The wave disturbances at entrance and inside the harbour should be in limit which may further necessitate the need for construction of breakwaters. The overlapping of the breakwaters at the entrance of fishing harbour is to be designed suitably for safe navigation and maneuvering of fishing vessels near the entrance. In the present paper, mathematical model studies for wave tranquility for development of a fishing harbour at Chethy in Alappuzha district of Kerala have been described. The proposed layout consisted of north and south breakwaters of the respectively of lengths 661m and 847m with entrance width of 150m. In order to reduce the wave height at the entrance and at the berth, the various alternatives for extension of south breakwater were studied using MIKE 21 BW. It is seen that with optimum 100m extension in the length of south breakwater, enough shelter area near the entrance for safe navigation of the fishing boats to the harbour is available and the significant wave height at operating berth is also reduced with total downtime from 35 days to about 9 days during the monsoon season.

**Keywords:** Fishing harbour, Wave Tranquility, Numerical model, Shoaling, Refraction

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Paper ID – 179

### **UTILIZATION OF NUMERICAL MODEL FOR SHORELINE CHANGES TO EVOLVE THE SUITABLE COASTAL PROTECTION WORK AT HOSABETTU, KARNATAKA**

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#### **Abstract**

Coastline is dynamic morphological interface which responses to the external forces exerted by tides, waves and near shore currents. As a result, it causes movement of sediment along coastline and erosion or accretion may occur. Coastal erosion is also loss of land area due to action of waves, Currents, wind and gradual increase in the sea level due to global warming. This problem becomes much more serious when severe damages occur to the manmade structures viz. buildings and roads etc. in cities situated very near to coastal line. In order to protect the coastline to avoid this damage, suitable coastal protection measures are required. In this present paper, suitable coastal protection works have been suggested through the numerical modeling for shoreline changes. The site is situated in the open coast at Hosabettu, in Mangalore, Karnataka and subjected to high waves of upto



4.5 m associated with significant littoral drift. As a result, the severe erosion takes place in some of the stretches along the shoreline. Also, some important buildings have been totally demolished due to this severe erosion. In order to stabilize the shoreline near Hosabettu, suitable coastal protection measures were suggested through Numerical model LITPACK in the form of; sixteen groynes of length 50m and spacing 200m along the coastline or as an alternative, ten offshore breakwaters of 100m length each at 200m spacing. The suggested coastal protection works are expected to stabilize the eroding coastline at Hosabettu.

**Keywords:** Numerical model, Groyne, Offshore breakwater, Erosion, Accretion

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Paper ID - 180

## SHORELINE CHANGES STUDIES FOR DEVELOPMENT OF PASSENGER TERMINAL AT KASHID, MAHARASHTRA

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### Abstract

Design of Passenger terminal is a complex process requiring consideration of site-specific environmental parameters such as wave, current and tide, littoral movement etc. Many a times, the effect of these parameters on the coastline changes due to the construction of breakwaters is significant. Adequate area for maneuvering of passenger vessels and berthing place, adequate depth and tranquility are essential requirements for development of a passenger jetty. Sometimes littoral drift becomes single most parameter which affects the design consideration. The sediment movement (Littoral drift) at the site and impact of development of the Passenger terminal on the coastline can be effectively assessed using the numerical modeling. In the present paper, the impact of the passenger terminal on the shoreline changes and morphological impact on the adjacent regions has been assessed using LITPACK studies. Littoral drift studies indicated that net littoral drift at the site of development is of the order of 10,000 cum only towards south. The simulations of shoreline changes carried out with LITLINE indicated that due to the construction of the breakwaters, there are no significant changes in the shore up to 5 years, but after 10 year less than 5 m accretion on north of the breakwater may occur which is almost negligible. The presence of rocky out crops on the north of breakwater would not allow any significant accretion or movement of sand. Consequently, the erosion on the south side of breakwater will too be negligible.

**Keywords:** Numerical model, Littoral drift, Passenger terminal, Breakwater, Layout

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**THEME - XIII**

**RS & GIS APPLICATION FOR RESOURCES MANAGEMENT**



Paper ID - 19

## Study on Vegetation and Rainfall Pattern for the State of Maharashtra

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### Abstract

Land use / Land cover pattern has been changing with civilization. The rainfall pattern changed significantly in the recent years. Dense vegetation is one of the significant factors that affecting the rainfall and vice versa. The present study pertains to the impact of dense vegetation on the local rainfall pattern in the state of Maharashtra. The area of very dense forest in Maharashtra is 8,027 sq.km and also increase in water bodies near forest area 432 sq.km from the year 2005 to 2015 as per reports published by Forest survey of India in the year 2017. This indicates that there is some relation between dense vegetation and rainfall. Filter Normalized Difference Vegetation Index (NDVI) data of Ocean Color Monitor (OCM2) sensor of IRS-P4 OCEANSAT-2 has been collected. The data have been classified into seven classes based on NDVI range using ArcGIS. The NDVI analyses showed there is an increase in vegetation initially and then it is decreased. The rainfall data have been collected from CHRS portal. The rainfall and NDVI data were analyzed using correlation analysis. Conclusion shows that there is a change in rainfall pattern with a decrease in vegetation.

**Keywords:** NDVI, Rainfall, NDVI classification, Correlation, ArcGIS

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Paper ID –36

## Estimation of surface heat fluxes using Remote Sensing Method

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### Abstract

Surface heat fluxes are most important parameters to investigate the interaction between surface and atmosphere. The main goal of this study is to calculate the surface energy fluxes with remote sensing data based on remote sensing algorithm to solve the energy balance equation on each data pixel. Surface Energy Balance Algorithm for Land (SEBAL) was developed by Bastiaanssen et al., (1998) is used for the study. Landsat OLI image for 19<sup>th</sup> February 2015 and 17<sup>th</sup> February 2020 are selected for the study. Cloud free image is necessary for the algorithm. Visible, near infrared and thermal infrared bands are used from Landsat OLI image. The surface energy fluxes are estimated by partitioning of available energy at the surface between Sensible Heat flux (H) and Latent Heat Flux (LE). The method is based on the hot (dry) and cold (wet) pixel selection and heat fluxes of that pixels. Reference evapotranspiration and wind speed are collected from CLIMWAT 2.0 provided by FAO. Results indicate that SEBAL method can be used for calculating surface heat fluxes at pixel level and for determination of its spatial distribution.

**Keywords:** Surface Heat flux, SEBAL, Remote Sensing

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Paper ID –37

## Assessment of grape crop acreage using geospatial technique for command area of Palkhed reservoir (Maharashtra)

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### Abstract

Realistic acreage estimation of cash crop like grape in the service area of irrigation projects is essential. The existing practices of crop measurement are tedious, time consuming and sometimes causes errors in measurement. Geospatial technique provides quick, accurate and cost-effective method for crop acreage estimation. This technique was adopted to estimate grape crop acreage in Palkhed irrigation command area which is rich in grape cultivation. Normally, for separating grape from other crops, multi-dates satellite images of 2 different periods, are analysed. In the present study, satellite images of two different period viz. December 2019, February 2020 were used to estimate grape crop acreage. The work of grape crop acreage estimation at village level comprises of two components. First one is remote sensing and the other is GIS. Remote sensing part covers the selection of appropriate satellite images, their analysis, pre and post analysis ground truth. The GIS part covers the collection of village maps / cadastral map, their geo-referencing, vectorisation and then rasterization of maps and overlaying of these raster maps to extract the land use statistics at village level. ERDAS IMAGINE, a standard image analysis software is being used for these studies. The paper presents in brief the methodology adopted, utility and importance of this technique for acreage estimation of grape crop area.

**Keywords:** Grape; Remote Sensing; Palkhed; Command; Analysis; Methodology

Paper ID –38

## Hydro-cover Mapping by Remote Sensing and GPS Technology: A case study of Nashik District, Maharashtra, India

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### Abstract

Hydro-cover maps are essential for many water resources as well as environmental applications. Accurate information of hydro-cover is important for flood prediction, monitoring and relief etc. The information of hydro-cover is difficult to produce using traditional survey techniques because water bodies can be fast moving as in floods, tides and storms etc. Remotely sensed data provide a means of delineating water boundaries over a large area on the date of pass of satellite. Hydro-cover mapping from satellite images remain a challenging task due to sensor limitations, the presence of clouds, topographic and atmospheric conditions etc. Various water body mapping approaches have been developed to extract water bodies from multispectral images. The objective of this study is to identify and map hydro-cover using remote sensing technique. This paper proposes a supervised classification methodology for hydro-cover mapping at district level. Resource sat-II satellite of LISS-III sensor (23.5m) resolution have been used for this study. The post-monsoon and pre-monsoon statistics for the water year 2019-2020 have been generated for Nashik district. About 450 ground truthing sets in the form of point, line and polygon using handheld GPS instruments are collected from various tahasils in Nashik district for analysis and validation purpose. The accuracy of the method is tested using ground truthing information. The proposed method produces the accurate results. The geographical area of Nashik district is 15530 sq.km. Hydro-cover area estimated in post-monsoon is 36985 ha that is around 2.38% of the geographical area and hydro-cover area estimated in pre-monsoon is 10518 ha that is around 0.68 % of the geographical area. The result discussed in this paper will provide fundamental information to state as well as local authorities for the protection and restoration of hydro-covers and conservation of natural ecosystem in Nashik district.



**Keywords:** *Hydro-cover, Remote Sensing, Supervised Classification, Ground Truthing.*

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Paper ID –53

## **A STUDY ON THE IMPACT OF WATER POLLUTION DUE TO DUMPING OF WASTE IN THE DEEPOR BEEL**

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### **Abstract**

Deepor Beel is a prominent and popular wetland located in the city of Guwahati in the state of Assam. The present study was carried out to analyze the water quality parameters of the beel and to check how these parameters were affected due to dumping of waste on and near the wetland area. A total of twelve parameters viz. Water temperature, Colour, Odour, Dissolved Oxygen, Biological Oxygen Demand, Total Alkalinity, pH, Turbidity, Total Hardness, Chloride, Iron, Nitrate were tested during the period from August 2019 to June 2020 at six locations around the beel. Standard methods were followed for the collection, sampling and analysis of the water quality parameters. The data obtained from the laboratory test were statistically analyzed using SPSS (ver. 22) software. The results indicated certain parameters are higher than standard permissible limits with extreme values of the results been obtained at the dumping location at Boragaon. The water near the dumping site is acidic (pH= 5.92), with high iron concentrations (3.68 mg/l), increasing hardness and turbidity as well as lower D.O level (3.67 mg/l). The Anova analysis indicated that there was significant difference in certain water variables such as alkalinity, iron, total hardness, nitrate, chloride, D.O, B.O.D (basically temporal variation) as F-ratio  $\gg 1$  and p-value  $\ll 0.05$ . Moreover, the correlation matrix upholds a distinct correlation among various parameters with both positive and negative indications. Hence the present study showed that water quality is deteriorating gradually at various locations of the beel.

**Keywords:** *Wetland, Deepor Beel, Water quality parameters, Dumping site, Anova.*

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Paper ID –70

## **Impact of land use land cover on the response of the Mahanadi river basin in a sub-basin scale using SWAT**

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### **Abstract**

Land use activities, development and management of water resource are interdependent and thus land use/land cover (LULC) change has significant impacts on water quantity such as surface runoff, groundwater, over a range of temporal and spatial scales. The land-water interactions need to be addressed to determine whether they represent the best available information and supports decision making processes for developmental activities in a sustainable way. This article has focused on the hydrological modelling of the Mahanadi river basin on sub-basin scale which is situated in the states of Odisha & Chhattisgarh in India. In this article, the hydrological modelling has been done using “SWAT (Soil & Water Assessment Tool)” along with GIS interface. The data used in this study are the Digital Elevation Model (DEM), Land Use Land Cover (LULC), Soil, rainfall, relative humidity, wind speed, temperature, solar radiation. At first, the basin was delineated into various sub-basins. Then four sub-basins were considered and further delineated to generate smaller sub-basins. Then the newly generated smaller sub-basins were further divided into HRUs (Hydrological Response Units) based upon unique land use, slope & soil data combinations. Runoff was simulated separately for each of the four sub-basins. By using SWAT-CUP, the parameters sensitive to runoff were pinpointed & their optimized values were taken into



consideration for model calibration. The simulated values were validated against field values. Here SWAT was used to simulate the impact of land use pattern, soil type, slope class & different weather conditions on runoff in a sub-basin scale. Model performance was administered or each of the five sub basins using the Nash–Sutcliffe model efficiency coefficient (NSE). The model efficiency was found to be satisfactory for both calibration phase validation phase within the SWAT model. It was found that cultivation land and urbanisation appear to be major environmental stressors affecting local water resources at the sub basin scale. As a result, increased runoff, decreased percolation, and increased evapotranspiration has a detrimental impact on the Mahanadi River Basin. This study can motivate the policymakers and experts to formulate and implement appropriate and sustainable response strategies to minimize the undesirable effects of land use land cover changes.

**Keywords:** SWAT, HRU, SWAT-CUP, DEM, LULC, NSE

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Paper ID –80

## Hydrological Modeling of the Upper Cauvery River Basin Using SWAT

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### Abstract

Hydrological modeling of river basins is an important numerical tool for understanding, predicting and managing water resources. Soil Water Assessment Tool (SWAT) is applied to the Upper Cauvery river basin located in southern India to simulate the streamflow discharge, identify the sensitive parameters, and analyze uncertainty in the river basin. The hydrological assessment is useful for the hydrologist, water resources engineers involved in water supply, agricultural management and climate change, as well as the water auditing for water disputes. A GIS environment Arc SWAT module was used to develop the hydrological model of Upper Cauvery basin and all database was developed to run the model. SWAT-CUP software module SUFI2 was used to analyze the sensitivity and uncertainty of the model parameters. The results of model calibration and validation suggest a good match between the measured and simulated streamflow and hence can be used for predicting scenarios such as climate scenario, land use land cover scenario and cropping pattern scenario.

**Keywords:** Hydrological Modeling; Upper Cauvery River Basin; SWAT; SWAT-CUP; Sensitivity Analysis; Uncertainty Analysis

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Paper ID –102

## Comparison of Land Surface Temperature for Bare soil from MODIS and ASTER data

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### Abstract

Land Surface Temperature (LST) is known as the radiative skin temperature of the surface of earth and it has a major role in water balance and surface energy of earth. LST has wide applications in different fields like evapotranspiration, climate change, urban climate and environmental studies. Ground based measurements of LST is not practically possible, but satellite sensors in the region of thermal infrared are used for LST estimation. The Moderate Resolution Imaging Spectroradiometer known as MODIS, having a good temporal and spatial resolution is one of the commonly used sensors for land surface temperature monitoring. The product of collection 6 MODIS(C6) LST is now accessible for the public users and has been refined for bare soil



pixels. This study compares the MODIS C6 LST product's accuracy in three study areas of bare soil lands. The calculated RMSE and bias of the temperature differences ( $MODIS_{LST} - ASTER_{LST}$ ) between MODIS C6 LST and ASTER LST indicates that the accuracy of MODIS C6 LST has notably improved, than the collection 5 MODIS (C5) LST. Effect of seasons over the accuracy of LST showed that RMSE and bias of the differences ( $MODIS_{LST} - ASTER_{LST}$ ) between the MODIS C6 LST and the ASTER LST during summer season is higher than that of winter season. This may be attributed to the high amount of water vapor column in the atmosphere in summer season, since the standard LST or emissivity algorithm of ASTER is poor in compensating the atmospheric effects in the presence of higher amount of water vapour in the atmosphere.

**Keywords:** Land Surface Temperature, MODIS, ASTER

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Paper ID –164

## HYDROLOGICAL GEOPHYSICAL AND GIS APPROACH IN DELINEATION OF SUITABLE ARTIFICIAL RECHARGE SITE

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### Abstract

Potable groundwater availability is one of the prime global issues of the 21<sup>st</sup> century, apart from food security and environmental degradation. In the recent past, several provinces in India have faced severe scarcity of potable groundwater. In view of the same, several projects have been initiated to augment the depleting ground water resources by harvesting surface runoff and recharge the groundwater aquifer system. One of the most feasible strategies available to overcome the scarcity problem in drinking water sector is by adopting suitable water harvesting and artificial recharge strategy. Water harvesting and artificial recharge are two important scientific interventions to remediate most of the drinking water scarcity problems. Suitable site delineation is one of the prime requisite for implementing water harvesting and recharge structures. Geo-hydrological studies, Geophysical investigation and application of GIS are the major tools for the above said purpose. In this paper the author has attempted to emphasize the significance of surface geophysical investigation followed by infiltration tests, tracer studies, GIS etc., at various site locations with few significant case studies from southern province of India.

**Keywords:** Infiltration test, resistivity investigation, Artificial Recharge, GIS.

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Paper ID –170

## Estimating the impacts of Land use and Land cover on soil properties of Puttur

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### Abstract

Many studies show that population growth is the main factor for the land use/land cover changes, which impact on climate change, soil properties and socio-economic changes. In this study, an attempt is made to estimate the impact of land-use changes on soil properties. The land use/land cover changes of the study are determined using Resourcesat2, LISS-4 images of 2008 and 2019. ArcGIS 10.7 and ERDAS Imagine 2019 software was used to classify individual classes like agriculture, mixed forest, water bodies, built-up area,



barren land and river bed. There was a rampant conversion of forest land to other land uses. The study concludes that land-use changes have an impact on soil properties such as Organic Carbon, nitrogen, Electrical Conductivity, pH, dry density and Potassium.

**Keywords:** LULC, soil properties, agricultural land, mixed forest, water bodies, built-up area, barren land, river bed

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Paper ID –219

## Estimation of Soil Loss from Bagmati River Basin using RUSLE model and GIS Technique

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### Abstract

Soil loss has become a major issue these days that take place from pasture, barren land and from other practices. Bagmati, a tributary of the River Ganga, is a perennial river of Nepal and India. During monsoon it carries heavy discharge with huge amount of sediment, which is eroded from the hilly region of the basin. After emerging from the hills, their slope gradually becomes flatter towards the plains, thereby reduces the velocity, resulting in deposition of sediment on river beds. This reduces the carrying capacity of river and flood water overtops the bank causing inundation of the adjoining areas, which causes loss of life, property, environment etc. By knowing the soil loss prone area proper planning for soil conservation can be done in appropriate time. Soil loss leads to the loss of sediments and also reduces the fertility of agricultural land, so its estimation is very important. In this study, RUSLE method has been used to estimate the soil loss and to prepare the soil loss map of Bagmati river basin. The various factors of RUSLE model have been computed using ARCGIS Map along with Remote Sensing and GIS tools. The map of these factors - rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), cover management (C) and conservation practice (P) have been prepared using ArcGIS. Based on these data, loss maps have been prepared for the years 2013 and 2014 using RUSLE model. The soil loss for year 2013 and 2014 were 727.236 t/ha/yr. and 889.33 t/ha/yr., respectively.

**Keywords:** Soil loss; RUSLE; ArcGIS; Bagmati River Basin

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Paper ID –228

## Dynamics of land use and land cover change (LULC) using geospatial techniques: A case study of Mahanadi River basin, Odisha.

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### Abstract

Change in land use and land cover patterns has a significant contribution to hydrological cycle. Understanding the pattern of LULC is a great aspect of watershed management, so this study discusses the dynamics of LULC changes on Mahanadi river basin from 2002 to 2020. One of the detailed and useful ways to develop land use



classification maps is use of geospatial techniques such as remote sensing and Geographic Information System (GIS). This work gives an insight on the accurate, quick and economical procedure for mapping land use and land cover of any specified area of interest. Satellite images can provide useful information regarding spatial and temporal variation of LU/LC in an area. In the present study, assessment of LULC and their change detection were carried out using digital image processing techniques. In order to study LULC changes in Mahanadi River basin, multispectral satellite images were used for three Epochs; 2002, 2010 and 2020. For the year 2002, 2010 and 2020 LANDSAT images were obtained for the month of January from United States Geological Survey (USGS). Spatial data such as MODIS LP DAAC satellite data and maps are downloaded from USGS website. Present research elaborates on 17 land use classes as per the Land use land cover data from MODIS LP DAAC Data Pool of USGS Earth explorer. A significant change in the pattern of LULC is noticed for the Mahanadi river basin. The main cause behind this change was economic development, significant change in climate and rapid population growth. Urbanization and deforestation resulted in a wide range of environmental impacts, including degraded habitat quality. The developed LU/LC maps are providing insight to possible changes and helps managing in agriculture, forest, urban, and water resource planners and managers in improved policy-making processes.

**Keywords:** *Land use/land cover, GIS, Remote sensing, Mahanadi river basin.*

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Paper ID –230

## **Study of Morphological Changes of River Ganga from Patna to Mokama during 1975 to 2019 using satellite imageries**

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### **Abstract**

Ganga River is one of the major rivers of the Indian subcontinent. It is a lifeline to the people who reside along the bank of the river. It is also considered as the most sacred river and worshiped as a goddess by people. Ganga River is an alluvial river and morphological changes has been a common phenomenon. During 1975–2019, river has undergone considerable changes in its morphology due to natural and manmade interference and shifted from its original course causing major loss of agricultural land. Therefore, study of morphological changes is very important to understand the behaviour of the river. In this study, morphological changes of river Ganga from Patna to Mokama during 1975 to 2019 has been studied using satellite imageries and ARC-GIS Technique. This area is highly populated and major populations of this area reside near the bank of river Ganga. Shifting of river bank put these areas under risk of submergence in flood seasons. Morphological parameters such as sinuosity, braiding index, braiding ratio, Braid-Water ratio, area of island area, water covered area have been computed over the periods of 40 years, at an interval of 5 years and analyzed. The results indicate that river is sinuous and braided in nature and the left bank is more susceptible to the erosion and deposition as compared to the right bank. The variations in the morphological parameters are significant due to varying erosion and accretion rates during the period of study.

**Keywords:** *ArcGIS, river Ganga, Morphology, Braiding Index, and Sinuosity Index.*

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Paper ID –235

## STUDIES FOR PROPOSED BANK PROTECTION WORKS ALONG EXISTING GHATS OF NIRA AND BHIMA RIVERS AT NIRA NARSINGPUR, MAHARASHTRA-A CASE STUDY

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### Abstract

River Nira joins River Bhima near village Nira Narsingpur, Indapur Taluka, Pune district, Maharashtra. The famous Sri Laxmi Narasimha temple is located at the confluence of these rivers. There are five ghats along these rivers for use of devotees and village people. Two ghats are on left bank of River Nira and two ghats are on right bank of River Bhima and one ghat is at the confluence. These ghats were constructed long back using black stone with provision of steps articulated over the sloping banks of the rivers. These ghats are working as a slope protection and are protecting the banks from erosion. Due to undermining of foundation, ghats have disturbed at few locations. In order to strengthen the ghats from further erosion/damage, Executive Engineer, PWD, Pune east approached CWPRS with a proposal of renovating the existing ghats. Project authorities proposed stone crated gabions for slope protection works and a vertical gabion wall for toe protection at the edge. The studies were conducted for verification of proposed protection works and necessary modifications were suggested wherever necessary. The proposed design of gabion wall for toe protection was found to be safe against overturning, sliding and bearing. The design of proposed slope protection works as per the given hydraulic parameters of river and in terms of river training methods appeared to be safe and was recommended to be adopted for the protection of ghats along River Nira and River Bhima.

**Key words:** Gabion wall, erosion and scouring, Geo-fabric filter, Toe wall, launching apron, etc.

Paper ID –236

## A COMPARATIVE STUDY ON THE AIR TEMPERATURE TRENDS IN COASTAL AND INLAND REGION OF INDIA

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### Abstract

Air temperature is one of the crucial Meteorological parameters to determine the variability of climate of that region. It is an index of climate change determination. Several meteorological data collected at the different Observatories/Meteorological stations are used for analysis of air temperature. The data are collected at coastal and inland regions of India. The analysis of air temperature data is useful for setting up of Atomic Power Plant by NPCIL, the results in the form of report is useful for preparing guidelines and design of setting up of Atomic Power Plants. The authors of this paper reviewed and analyzed the temperature data for a period of past forty years. The data collected at Meteorological stations at Kanyakumari, Kalingpatnam, and Bhavnagar are Coastal sites while at Mandla, Hissar, Shivpuri and Bansawara are inland sites. The analysis of the data is useful for various studies. The data in this paper are analysis and processed decade wise. The trends in each decade is noted. Air temperature in different processed parameters such as average maximum, average minimum is computed and plotted as histograms. All these it is as showed considerable trend in change of air temperature. This aspect could be considered in the direction of climate change determination, the methodology and results of



the study is discussed in detailed in this article.

**Key words:** *Meteorological data analysis, climate change.*

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Paper ID –267

## **Landslide prediction in Western Ghats using TRIGRS model**

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### **Abstract**

Landslides may pose a serious threat to human life and property and can change the natural landscape. Landslides are of many types, out of which rainfall-induced shallow landslide is the most common. The increase in heavy rainfall can increase the risk of rainfall-induced shallow landslides. Unforeseen climatic conditions in August 2018 triggered a huge number of landslides in the hilly regions of Kerala which affected thousands of people directly or indirectly. It had devastating impacts on the infrastructure. Thus, accurate landslide susceptibility assessment is the basic and effective tool for reducing the impacts of such disasters. This study aimed to find a suitable method to create the Landslide Susceptibility Map of Idukki district. A numerical model with some amount of empiricism viz, Transient Rainfall Infiltration and Grid-Based Regional Slope Stability (TRIGRS) is used to create LSM of Idukki district, Kerala, India. TRIGRS model takes spatial variation in geologic, geographic, and topographic characteristics and spatial and temporal variation in rainfall. In most cases, soil depth maps of large areas is not available. This study tries to find a suitable method to create soil-depth maps from Digital Elevation Model (DEM) for running the TRIGRS model for creating the LSM of Idukki district. TRIGRS model using the derived soil depth map provided an accuracy of 73.24% (with 41.74% unstable area).

**Keywords:** *Landslide susceptibility map, Landslide, TRIGRS model*

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Paper ID –366

## **Flood hazard mapping of Netravati river basin using remote sensing and GIS techniques**

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### **Abstract**

Flood can be considered as one of the most devastating natural hazards because of its frequent occurrence and the losses it has caused worldwide. The consequences faced by the humans make flood management necessary. The study was done to map the flood hazard zones of Netravati river basin. Hazard considers the physical and statistical aspects of a flood. The study incorporated GIS with Multiple-criteria-decision making (MCDM) to map the flood hazard zones. Multiple-criteria-decision was solved by using AHP (Analytic Hierarchy Process). The study considered six physical factors: rainfall, slope, soil, LU/LC, population density and distance to river. The weight of each criterion was determined by using AHP and flood hazard map was developed. From the map we were able to identify the regions that are most likely to get affected when exposed to flood. A total of 56.81 km<sup>2</sup> is at very high hazard zone and 852.20 km<sup>2</sup> is at high hazard when a flood strike. 1484.12 km<sup>2</sup> of the total area of Netravati basin is in moderate hazard. 589.66 km<sup>2</sup> area of Netravati basin is at low hazard and 450.15



km<sup>2</sup> area of Netravati basin is at very low hazard. The regions that have lowest hazard value of flooding is located mainly at the eastern parts of the study area where the vegetation density is high. The map generated using the proposed methodology can be considered as reliable result and can be used for taking necessary precautions at areas that are depicted as high hazard zones.

**Keywords:** Flood hazard; GIS; multiple-criteria-decision-making analysis; analytic hierarchy process

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Paper ID –411

## Assessment of Water Balance Components in the Genale River Basin, Ethiopia Using SWAT Model

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### Abstract

To utilize water resources sustainably, understanding the quantity and quality of water resources in spatial and temporal variation is essential. Assessment of water availability is a vital aspect for planning, exploring, and management of water resources in the catchment for every country, especially for developing one. This study was initiated to evaluate various water balance components in the Genale River Basin, Ethiopia using physically-based semi-distributed Soil and Water Assessment Tool (SWAT) model. The data used in this study was included spatial data (Land use/cover, soil type, and digital elevation model) and temporal data (meteorological/daily climate and discharge data) for analyzing water balance components in the catchment. The delineated Genale watershed (54,942Km<sup>2</sup>) contained 25 sub-basins that encompassing 464 Hydrologic Response Units (HRUs). The calibration and validation of streamflow were performed from (1998-2007) and (2008-2012), respectively, using SUFI-2 at watershed outlet on Monthly basis. The model performance revealed curve number (CN2.mgt), available water capacity of the soil layer (SOL\_AWC.sol), and saturated hydraulic conductivity (SOL\_K.sol) are sensitive parameters to runoff respectively. Nash–Sutcliffe efficiency (NSE) for calibration and validation period was 0.77 and 0.71, and the coefficient of determination ( $R^2$ ) obtained was 0.82 and 0.80 during calibration and validation, respectively, which indicate satisfactory model performance in both cases on Monthly basis. From the simulation results, sub-basins located at upstream of the watershed, particularly sub-8 and 12 contained high water yield potential, while the low amount was recorded in the middle and downstream sub-basins. The soil water content, evapotranspiration, groundwater recharge from shallow/deep aquifer overshadowed in the Genale watershed. The reason is due to the type of scattered bushland cover, infrequent occurrence of rainfall events, and sometimes rise in temperatures in the dry seasons with a high speed of wind energy. Then, the decision-maker will enable sustainable management and identify the high potential area of water to recommend water resources planning and management practice.

**Keywords:** Water yield; SWAT; sensitivity analysis; SWAT-CUP; Genale watershed

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Paper ID –435

## SWMM based Integrated Urban Stormwater Management for a Water Sensitive City: A Case Study of Proposed Amaravati City, Andhra Pradesh

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### Abstract

Stormwater drainage and its management in urban regions have become a challenge because of the rapid and random expansion of urban areas, deletion of plant life, and reduction in the efficiency of drainage infrastructure. A few of the challenges are stormwater management in terms of water quantity and water quality. Stormwater management model (SWMM) is a dynamic rainfall-runoff simulation model used for single event or long term (continuous) simulation of runoff quantity and quality from urban areas. In the present study, SWMM has applied for the considered study area i.e. proposed Amaravati city of bifurcated new state of Andhra Pradesh. The present study focuses on evaluation of the performance of various Low Impact Development (LID) control options for efficient stormwater management with regard to reduction of runoff from the entire catchment of the study area. Various LID control options are used for certain portion of each sub-catchment area with a number of units. The performance of each LID control for each sub-catchment has determined in terms of surface outflow from each LID control and further decrease in total runoff from each sub-catchment. The present study finds peak runoff from each sub-catchment and from entire catchment of proposed Amaravati city. Also, an assessment of diverse LID controls with regard to NO LID control option has made in terms of attenuation percentage in runoff as a metric to adopt sustainable and/or resilient integrated urban stormwater management for the proposed Amaravati city to perform as a Water Sensitive City.

**Keywords:** Stormwater management; SWMM; LID; runoff

Paper ID –483

## Vulnerability Zoning of Urban Flood Using Remote Sensing and GIS in Hyderabad, India

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### Abstract

Flooding is an irresistible accumulation of water in an area from the combination of hydrological and meteorological extremes, such as excess precipitation and runoff. Hyderabad is the capital of Telangana state of southern India and is located on the banks of Musi River. According to researchers, Hyderabad's vulnerability to floods stems from the gradual demolition of a natural flood protection framework along with the erratic weather patterns brought up due to climate change. Under the Greater Hyderabad Municipal Corporation, the latest urban area extends around 923 sq.kms. With a population of 9.23 million, after New Delhi, it is India's third biggest city by area. Hyderabad witnessed several severe floods during the past two decades. Increase in population, industries, commercial establishments and rapid infrastructural development have put tremendous pressure on the urban water bodies of the city, reducing their area, quantity and quality. Improper urban



planning, encroachment of water bodies, inadequate drainage, and frequent occurrence of extreme weather events and lack of preparedness are the major causes of flooding in Hyderabad. The present study is carried out to identify the flood vulnerability zones in Hyderabad City using Remote sensing and GIS technologies. Flood vulnerability assessment is carried out using Multi-Criteria Analysis (MCA) method, integrating inputs from Remote Sensing to the Geographical Information System (GIS) software. Elevation, population density, density of water logging sites, distance of water logging sites and water bodies, are the thematic flood influencing layers considered. To assess the urban flood vulnerable area identification and zoning, the weighted overlay analysis approach was used. The cumulative flood vulnerability scores were generated by integrating thematic layers and the total area was classified into 4 zones as low, moderate, high and very high. The corresponding zonal areas are found to be 25.03%, 39.22%, 22.23% and 13.52% respectively. The present assessment would help in getting a quick and precise overview of areas that are prone for flooding and vulnerability zones and therefore provide reliable information on flood in flood risk assessment. This would be quite useful for urban planners, administrators, water managers, decision makers and disaster management authorities while preparing flood management plans and in adopting relief management strategies.

**Keywords:** *Flood; Vulnerability; Zone; Assessment*

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**THEME – XIV**  
**SEDIMENT TRANSPORT**



## **Breakwater construction effects on hydrodynamics and sedimentation pattern in open coast**

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### **Abstract**

A coast is a geological system that is subject to constant movement and change. Shorelines, beaches, and coastal areas in effect affect human lives, and vice versa Sediment transport driven by current, wind and wave plays an important role in influencing the evolution of offshore and onshore bed morphologies by deposition and erosion. Government of Karnataka is keen to expand the fishing harbours and fish landing centres to give a new dimension to the livelihood of the fishing community. Hangarkatte Port lies at latitude 13°26'40.04"N and 74°42'8.09"E, at the mouth of Sitanadi and Swarra River at Hangarkatte in Udupi District. At present the navigation of this port is through sand bar. By construction of suitable breakwater and river training walls it is possible to develop this port into a regular all-weather port which will also serve as a fishing harbour. Hydrodynamics and sedimentation studies were conducted using MIKE 21 HD FM and MIKE 21 MT sediment transport models to study the tidal hydrodynamic behavior of flow and probable siltation pattern in the area of the proposed development of fish landing center at Hangarkatte and Kodibengre. The sea mouth entrance region opposite to Hangarkatte jetty acts as an approach for the two locations Hangarkatte and Kodibengre from the open sea. This inlet region has shallow patches and boats have difficulty to enter the estuary. To improve the navigation condition, it is proposed to a construct breakwater so as to give protection to Hangarkatte jetty. A proposed layout with two parallel breakwaters at the River mouth was studied and was found to be helpful to facilitate safe navigation of fishing boats and to keep the mouth, free from sand deposition. Sedimentation studies with Proposed layout indicated that the zone of deposition is mainly in the northern and southern side of the proposed breakwater as the two parallel breakwaters 950m (northern break water) and 680m (southern breakwater) are extended beyond the littoral zone (-3m contour) and also a slight tendency of erosion inside the inlet entrance is seen towards the offshore region which ranges from 5 to 10cm. From the hydrodynamic studies it was observed that with the proposed layout, consisting of parallel breakwaters with 200 m opening and dredging the channel and basin to -3m the current magnitude in the channel increased facilitating natural flushing of the channel to some extent. Sedimentation studies reveal that the maintenance dredging tends to increase in the basin area due to dredging upto -3m depth. The annual deposition of siltation is expected, as the velocities are weak compared to the existing condition at the fish landing area. This tendency of sediment deposition in the harbor basin needs to be tackled by maintenance dredging. Hence, based on the model studies the proposed layout is recommended for the development of fish landing centers at Hangarkatte, Udupi, Karnataka.

**Keywords:** *hydrodynamics, sedimentation, harbor, dredging, breakwater*

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## Interlinking prospect of Godavari River with Krishna River

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### Abstract

India is highly vulnerable to flood, so a major portion of its population is greatly facing problems every year due to the irregular distribution of rainfall in space and time. In 1980, Central Water Commission formulated a National Perspective Plan (NPP) in which an innovative plan called “Interlinking of Rivers in India” was approached for effective management of floods. The essential feature of this National Perspective Plan is to provide proper distribution of water by transferring water from surplus basin to deficit basin. Under NPP plan, about 30 interlinking of rivers are proposed to be done on 37 Indian rivers. The rivers in India are basic means of human beings as well as for wild-life. It also helps in irrigation, generation of electricity as well as a source of livelihood for the ever-increasing population. Hence most of the major cities of India are found to be at the banks of holy rivers. Due to uncertainty of Monsoon, proper management of river water is needed in India as the country invariably depends upon the agriculture. Moreover, the improper distribution of rainfall leads to severe problem in lack of irrigation in one region and water logging in others. So depleting status of water resources in India may be one of the most critical resource issues of the 21st century. So, the Present study investigates the purpose of river linking which is planned by Government of India for benefit and welfare of the society. It focusses on linking two or more rivers by creating a canal network manually and provide a land area that otherwise does not have river water access. Present study investigates the designing of canals which connects the river Godavari and river Krishna to control floods and to use surplus water for irrigation and other purpose. Manning's method is used for design of canals. Flood frequency analysis has been conducted for both the rivers. These analyses have been proven to be great asset to our planning. The magnitude of Krishna river floods has greatly been declined over the years and the chances of floods in Krishna are very slim. Whereas there are chances of floods in Godavari. It is planned that the flood water can be diverted to river Krishna. These promising results have increased the possibility of success of our planning. The principal objective is to draw water from Godavari river to Krishna river which can be done by connecting the Polavaram right canal to Krishna river at Ibrahimpatnam and thereafter to Srisailem Dam.

**Keywords:** River linking, flood frequency analysis; Manning's  $n$



Paper ID –149

## **Estimation of Sediment Production Rate using Josh and Dash model- A case study of Rel River, Banaskantha District**

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### **Abstract**

Spatial changes in rainfall are observed in India since past few years due to climate change and associated changes in the Indian summer monsoon circulation and the general atmospheric circulation. This indicates increase in rainfall parameter in western zone. Effect of this phenomenon is started to reflect in the semi-arid region of Gujarat and Rajasthan; a drought prone region which experienced severe flash floods in the years 2017 and 2015. This flood water carried unprecedented amount of sediments in the downstream. This research paper is aimed at estimation of sediment production rate of rel river sub watershed located between 24°29'15" to 24°46'18" North latitude and 72°0'28" to 72°27'5" East longitude covering 441.58 sq. km area in Gujarat Rajasthan boundary region. Sediment flow from the sub watershed during the floods in July 2017 posed a greater disaster in the localities near the outlet of sub watershed. Dhanera, a tehsil located in Banaskantha district located near the outlet of the sub watershed was sunk under 1 to 2 feet thick layers of muck disrupting many lives and properties. It took almost 2 months for Dhanera to stand up again. Estimation of sediment production rate will be helpful in selecting techniques for soil conservation. Moreover, we have classified the sub watershed into 52 micro watersheds and ranked them in the ascending order of sediment production rate. This guides to prioritize the sub watershed for urgency of soil conservation measures to be adopted. For this analysis geospatial technology such as Geographic Information System and Remote Sensing technology are used.

**Keywords:** *Summer monsoon rainfall western shift, sediment production rate, soil conservation, Geographic Information System*

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## Evaluation of hydrodynamics and sedimentation due to construction of jetty

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### Abstract

Gujarat with its favorable location and availability of a long coastline is a prime destination for executing maritime economic activities. The increasing importance attached to maritime economic activities has further led to the development of many port related activities. Okha port is an all-weather, non-major intermediate port handling dry- bulk cargo, owned and managed by the Gujarat Maritime Board (GMB). It is located in the North-West coast of Saurashtra Peninsula, at the mouth of Gulf of Kutch, Devbhumi Dwarka District, Gujarat. Hydrodynamics and sedimentation studies were conducted using MIKE 21 HD FM and MIKE 21 ST sediment transport models to evaluate the tidal hydrodynamic behavior of flow and probable siltation pattern in the port area with a 200 m x 20 m proposed Jetty. The computational model considered for tidal flow and sediment simulation covered an area of 22 km x 18 km. The model area covers the jetty region including the Beyt Dwarka jetty. From the hydrodynamic studies it was observed that with construction of proposed Jetty and approach channel there is no cross flow which is conducive for the proposed development. The siltation observed in the Jetty area and approach channel is very less this may be attributed due to the hard strata/ rocky bed in the vicinity, which indicates that the proposed jetty construction is feasible from siltation point of view.

**Keywords:** hydrodynamics, sedimentation, harbor, dredging, breakwater

## COMPARISON OF SEDIMENTATION IN DREDGED OPEN BASIN AND ENCLOSED BASIN– A CASE STUDY

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### Abstract

Technical feasibility and maintenance cost of any harbour play an important role in deciding its layout. Cost of Maintenance dredging is a major factor in maintenance cost of a harbour. In general, it is observed that obstruction of flow causes sedimentation in the area but this is not always true. The other phenomena which is important in sedimentation is the amount of sediment flux moving over the dredged area as part of sediment flux gets trapped in the dredged area and the tidal exchange. This phenomenon was observed while carrying out studies for Mormugao Port Trust to develop POL berth, fisheries harbour, Passenger, Port craft jetties and Mooring dolphins in Vasco bay, Goa. Maximum spring tidal range in at Mormugao is 2.4 m while the maximum currents in the area are 0.30 m/s. The bed material in the Vasco bay area is of soft - silty - clayey type. The proposed developments in Vasco bay included construction of; a POL berth (length 294 m) dredged to (-) 13.1 m below chart datum, Passenger jetty and Port craft jetty and a fisheries harbour dredged to (-) 3.1 m and Mooring dolphins. The studies indicated that the Scenario – II with solid bund structures has been found to be more suitable from the considerations of maintenance dredging compared to Scenario – I with piled structure and maintenance dredging would reduce to 0.22 Mm<sup>3</sup> from 0.34 Mm<sup>3</sup>. In the present study, 2-Dimensional hydrodynamic model MIKE 21 HD, spectral wave model MIKE 21 SW and mud



transport Model, MIKE 21 MT have been used to simulate the flow field and sediment transport in the existing and the proposed scenarios under prevailing tidal and wave conditions.

**Keywords:** *Tide, current, sedimentation, maintenance dredging.*

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Paper ID –197

## **Erosion of river Ganga upstream and downstream of Farakka Barrage- A review**

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### **Abstract**

The Himalayan Rivers continuously change courses in their lower reaches and the Ganga and its tributaries are no exception. The river Ganga has continuously changed its geometry of meandering in West Bengal during the last three decades. Migration of river Ganga towards the left bank upstream and right bank downstream of the barrage has resulted in unprecedented erosion of the left bank towards Malda district upstream of the barrage and its right bank towards Murshidabad district downstream of the barrage. In an uncontrolled regime, the changing course of the river is governed by skewed hydrography, bank-stratigraphy, influent and effluent seepage, sediment load. After construction of Farakka barrage, the dynamics of bend migration changed appreciably. The sequential maps help to understand how the river Ganga has changed its course. During the period 1968 to 1990, the upstream meander has migrated towards left bank by about 3 km eastward with an average migration rate of about 136 m per year. Between 1990 and 2005, it has further migrated about 4 km eastward which corresponds to an average migration rate of about 266 m per year. On the downstream side, the right bank of the river also has similar erosion problem. Continued erosion of the river upstream and downstream of the barrage has resulted in colossal loss of agricultural and household properties and subjected the poor people living on the banks to unimaginable sufferings. Two Experts Committees (P. Singh Committee in 1980 and G. Keskar Committee in 1996) constituted to explore the possible remedial measures to combat erosion, submitted their reports. Both committees recommended revetments with boulders to protect the banks from impinging currents and construction of spurs to deflect the flow towards the opposite bank. The Government of India has recently constituted the Ganga Control Authority with the objectives of pollution abatement and restoration of minimum ecological flow. It is equally important is to design a scientific land use plan for the flood plain of the river Ganga which shifts its course like a pendulum in the lower reach.

**Keywords:** *river Bank Erosion; Sediment Load; Skewed Hydrograph*

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## A Study of Flow and Sediment Transport Analysis using HEC-RAS

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### Abstract

River engineering is defined as controlling and predicting river behaviors and evaluate the sediment transport, which are utmost important for the hydraulic engineers now-a-days. The design of a model to determine the water conveyed with minimal erosion and sedimentation. The HEC-RAS model can perform the mobile bed sedimentation with computed an unsteady (hydrograph) flow series data. The conceptual and physical parameters required the HEC-RAS model were determined through calibration and direct measurement, and different parameters used in sediment transport analysis. The saint-venant (continuity and momentum) equation is then solved in the variation of discharge with time along the length of the water body, using the real-time sedimentation. Manning's roughness coefficient value is calibrated and simulated using the HEC-RAS model using the discharge of unsteady flow measurement, sediment discharge, and deposition rates at different levels of flow in the river. Herein, the main objective of the work is to analyze the flow and sediment transport simultaneously for Jaraikela-Panposh reach of the Brahmani River of length 37 km. The calibration and validation was carried out for the Mannings's roughness coefficient (n) and optimal sediment transport function (STF), using daily sediment-discharge time series data from 01-January, 2001 to 31-December, 2001 and from 01-January, 1996 to 31-December, 2000. From performance evaluation measures, the optimum 'n' value was found to be 0.05 and optimum STF is found to be Mayer Peter Muller method. During the calibration of 'n' value, the performance evaluation measures such as Nash and Sutcliffe Efficiency (NSE), Root Mean Square Error (RMSE) and Coefficient of determination ( $r^2$ ) were found to be 97.13%, 130.95 m<sup>3</sup>/s, and 0.97 respectively. Similarly, during calibration of optimum STF, the performance evaluation measures such as NSE, RMSE and  $r^2$  were found to be 95.97%, 155.14 m<sup>3</sup>/s and 0.97 respectively. In this study it is concluded that the HEC-RAS can be used for simultaneous analysis of both flow and sediment transport very efficiently.

**Keywords:** HEC-RAS; Sediment Transport; Unsteady Flow; Flow Routing; Brahmani River.

## FLOOD PROTECTION MEASURES AND ANTI EROSION WORKS ALONG PALHORI KHAD TRIBUTARY OF RIVER YAMUNA.

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### Abstract

Palhori Khad is a tributary of River Yamuna. Palhori Khad and its various Nallahs are flashy torrents which pose threat to valuable cultivated lands of this region during rainy season. The flood rises very fast due to reducing longitudinal slope and conveyance of the river downstream. For the past several years, flooding of banks and bank erosion is affecting the development of villages and agriculture lands on both the banks of Palhori Khad. Heavy floods occurred during the year 2013-14 that washed away the crops in 400 acres of land and farmers had suffered huge revenue loss. The construction of the embankments (levees) would help in



passing the floods easily as the flood wave would not get attenuated and conveyance of the river would be higher. In view of this, Govt. of Himachal Pradesh has planned to take up flood protection measures along the affected reaches of Palhori Khad. The study reach of Palhori Khad for a length of 7.1 km from upstream of Palhori village to boundary of Haryana and Himachal Pradesh was simulated in mathematical model HEC-RAS using 25 river cross sections. The discharge given by project authorities 173.88 m<sup>3</sup>/s is used for proving studies and the discharges obtained as per CWC flood estimation method for western Himalayas (Zone 7) are used for designing the flood embankments along Palhori Khad. The analysis of the results indicated that the heights of the protection works proposed by project authorities are overtopping at some locations with the discharge of 1 in 50 years and 1 in 100 years return flood. In view of this, CWPRS has recommended to increase the height of embankments for safe passage of flood. In this paper the probable causes, mechanisms and methods of predictions of bank erosion and sustainable strategies of different bank protection measures are briefly discussed.

**Keywords:** *Water levels, velocity, afflux, free board, slope protection, launching apron.*

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Paper ID –250

### **Estimation of sediment yield in Chalakudy River**

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#### **Abstract**

Neural networks are a user-friendly alternative to physically complex models for the prediction of soil erosion. The purpose of the study is to find out the best Artificial Neural network model for predicting the sediment yield by considering different input parameters like discharge, rainfall and flow velocity. The input data for a period of 28 years (1990 to 2018) were considered for this study. Models were developed for two periods 1990-1997 and 2010-2017. Five years of data were used for training the model and the remaining two years of input data were used for validating the model. The training was conducted using the Levenberg – Marquardt algorithm. For selecting the best performing model, minimum value of RMSE and NSE were taken as criteria for the evaluation of model. From the analysis of result, it was found that the Discharge – Rainfall model gave the best results in predicting the sediment yield.

**Keywords:** *Artificial neural network; Sediment yield; Chalakudy River*

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## 1-D hydrodynamic modelling in HEC-RAS for prediction of water levels and sediment transport in Narmada River

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### Abstract

Sediment transport modeling is intricate as various parameters like fluid characteristics, soil type, shape, size of the particles and, turbulence in the fluid is responsible for particle movement. Prediction of water levels and sediment transport across the river could help design the hydraulic structure. The 1-D hydrodynamic model was developed using HEC-RAS from Barmanghat to Handia to predict the water levels and sediment transport. The daily discharge and water levels and bed material size was collected from CWC, Bhopal and geometric data collected from India-WRIS for four stations, namely Barmanghat, Sandia, Hoshangabad, and Handia of Narmada River for 2011 and 2013 monsoon period. The calibration and validation of the model were done for Manning's n by comparing water levels at Sandia and Hoshangabad. The calibrated Manning's value for the 2011 monsoon period was found to be 0.037 for Sandia and 0.035 for Hoshangabad with minimum RMSEs 0.5052 m and 0.5158 m, respectively. That Manning's n value validated for the 2013 monsoon period at Sandia and Hoshangabad, the RMSEs were obtained as 0.7921 m and 0.9425 m, respectively. The total load calculated using Yang's equation in the model. This study could help in the designing of water resources structures across the channels and flood management.

**Keywords:** Hydrodynamic Model, Simulation, Sediment transport, Calibration, HECRAS.

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**THEME – XV**

**SOFT COMPUTING TECHNIQUES IN WATER RESOURCES**



Paper ID – 44

## Estimation of Precipitation Using Support Vector Regression

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### Abstract

Prediction of precipitation is an ever-eluding problem in the field of Hydrology and Water Resources Engineering. For a country like India whose economy largely depends on agricultural, this problem becomes even more serious. Since ancient times there were attempts made to predict precipitation over a catchment or a region or a country as well with leading time of few days to few months as well. However accurate prediction of precipitation on local or regional level for daily, monthly or even yearly basis is not fully accomplished. The present work is an attempt to estimate precipitation on monthly and yearly basis for the City Pune in India using data driven technique of Support Vector Regression (SVR). Meteorological parameters like cloud cover, vapour pressure and temperature measured over a span of 100 years are used to develop a SVR based precipitation model. Accuracy of the model is assessed by the value of coefficient of correlation between model predicted and observed precipitation. The SVR Model trained for the monthly data gives better fit for precipitation when compared to the model trained for annual data.

**Keywords:** Support Vector Regression; Precipitation estimation, Data driven technique.

Paper ID – 138

## Water Management of Canal Command Area of Upper Ganga Canal using Teaching Learning Based Optimization Algorithm

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### Abstract

One of the oldest irrigation canal systems in India commissioned as far back as 1854-55 on mighty Ganga River is Upper Ganga Canal (UGC). The command area spreads into the districts of Uttar Pradesh and Uttarakhand and irrigates nearly 9,000 km<sup>2</sup> of fertile agricultural land. The existing cropping pattern may not utilize the available resources due to poor economic efficiency that result in less water discharge in main stream of river Ganga. Therefore, an attempt has been made to optimize the net benefits under existing land and water resources using an evolutionary algorithm Teaching Learning Based Optimization (TLBO) method. It was revealed through the results that under the optimal cropping pattern, 1.2 % increment is obtained in net profit with 7.3 % reduction in water consumption.

**Keywords:** Upper Ganga Canal, Water Management, Optimal Cropping Pattern, Teaching Learning Based Optimization (TLBO)



Paper ID – 171

## Maximum and Minimum Temperature Prediction Using Hybrid Wavelet Transform – Neural Network Approach: A Case Study of Mahabaleshwar City

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### Abstract

Temperature prediction is beneficial to individuals, as well as for organizations whose workers and machines are to be operated in the open space. Accurate prediction of maximum and minimum temperature also helps in the prediction of evapotranspiration, rainfall and heat-wave condition. Also, from view of plant growth, temperature prediction is very important. In this research, a wavelet transform-artificial neural network (WANN) hybrid model has been developed for maximum and minimum temperature prediction. In this paper, using Daubechies wavelets of order 3 (db3), 4 (db4) and 5 (db5), the observed raw data was decomposed, upto 5<sup>th</sup> level, via discrete wavelet transform (DWT), which were fed as input to ANN naming WANN for temperature forecasting. Temperature data from January 1997 to October 2011 of Mahabaleshwar City situated in Western Ghats Range of Maharashtra, India, were used in the study. The maximum and minimum temperature values were forecasted for lead times 1 day, 2 days, 3 day, 4 and 7 day and the models performance was evaluated using root mean square error (RMSE), mean absolute error (MAE), and determination coefficient (R<sup>2</sup>). The value of R<sup>2</sup> is found to vary from 0.990 for both maximum and minimum temperature for 1-day lead time to 0.910 (max. temp.) and 0.838 (min. temp.) for 7 day lead time for WANN model as against 0.897 (max. temp.) and 0.773 (min. temp.) for 1 day lead time to 0.685 (max. temp.) and 0.435 (min. temp.) for 7 day lead time for ANN model. It was also observed that with increase in wavelet order and decomposition level, WANN models efficiency was increased.

**Keywords:** Artificial neural network, temperature, Wavelet transform, Daubechies wavelet, time series

Paper ID – 287

## Forecasting of Koyana Reservoir Outflow Using M5 Model Tree

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### Abstract

Dams and reservoirs are essential infrastructures that play vital role through the two major functions of water conservation and flood control. These functions require efficient reservoir operation along with effective control on the outflow of a reservoir. Consequently, precise forecasting of reservoir outflow is an important task. Koyana dam, one of the major dams in India, constitutes its reservoir outflow with water release to 4 different sections and water loss components. Hence it is a tedious job to predict the accurate outflow of Koyana reservoir for few hours to few days in advance. In the present study, M5 Model Tree is applied to forecast the outflow of



Koyana reservoir for 24 to 72 hours in advance. M5 Model Trees is a hierarchical modular approach which effectively splits the instance space into sub-spaces recursively and constructs piece wise linear regression

models for every individual subspace. The splitting criteria of Model tree minimizes the intra-subset variability (standard deviation) in the target values which helps to improvise the prediction accuracy. To develop outflow forecasting models, previously measured data at Koyana reservoir from 2000 to 2007 of reservoir inflow, storage and water releases along with losses is used. Performance of these models was judged by three standard error measures and scatter plots. The results indicated a promising role of M5 Model Tree in predicting reservoir outflow for all time intervals. Details of results along with scatter plots will be presented in the full manuscript of the paper.

**Keywords:** Reservoir modelling, M5 Model tree, data driven techniques.

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Paper ID – 325

## Streamflow prediction using the physics informed data-driven approach

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### Abstract

The streamflow prediction plays a crucial role in sustainable water management, design of hydraulic structures, flood mitigation, etc. At the same time, it is challenging to predict due to the complex behavior of different physical processes. The physics-based models are often used for hydrological modeling. But, the recent development in the field of artificial intelligence has improved its applications in the field of hydrology. Both of the physics-based and data-driven approaches have their own strengths and limitations. Physics-based models are based on physical laws, while data-driven models can understand complex relationships in data. Here we have proposed the physics informed data-driven approach that incorporates the advantages of both approaches. The Soil and Water Assessment Tool (SWAT) is used for daily streamflow estimation of the Panchganga river basin, and its output is further processed with the Long-Short Term Memory (LSTM). In recent years it is observed that LSTM has grown in importance in time series applications due to its ability to learn long-term memory dependence. The performance of the given approach is assessed by comparing it with the data-driven model and the SWAT model. Various statistical indicators like Nash-Sutcliffe Efficiency (NSE), Mean Absolute Error (MAE), Root Mean Square Error (RMSE), etc., are used for performance assessment. The physics informed data-driven approach outperforms the other two models. It has significantly improved the results obtained in the SWAT model. Its robustness can help in daily streamflow prediction at better accuracy. Further, this approach can be explored for flood forecasting at finer temporal resolution.

**Keywords:** Streamflow, SWAT, LSTM, Panchganga, Physics informed data-driven approach

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Paper ID – 367

## Gene Expression Programming for Prediction of Friction Factor in Open Channel Flow

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### Abstract

In open channel flow, the friction factor plays an important role to describe various hydraulic parameters and in the computation of conveyance capacity. Reynolds number and various resisting factors play pivotal role in determining the friction factor in the flow. This can be simulated in the laboratory and can also be determined by field measurements. In this paper the geometric and hydraulic parameters are analyzed and incorporated to determine the friction factor. However, it was found that friction factor varies with aspect ratio, sinuosity, slope (geometric parameter) of the channel and Reynolds number, Frouds number (Flow parameter) for the flow. Here laboratory data collected in a flume in the steady condition is used as the first set of instructions to a data-driven discovery technique i.e. Genetic Programming which ultimately manufactured the formulation of the expressions for friction factor. Various error analysis was done by separating the data set into training and testing data set. A good correlation was found between the discovered formula and the testing data set. Irrespective of the channel type (straight/meandering), channel cross section; this formula creates a common platform for evaluation of friction factor  $f$ . The objective of this paper is not only to understand the whole process but to demonstrate an alternative discovery way for the problem.

**Keywords:** Darcy-Weisbach coefficient, aspect ratio, bed slope, sinuosity, Reynolds Number, Frouds Number, Gene expression programming, chromosomes

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Paper ID – 434

## Development of Leak Detection Techniques in Water Distribution System using combined Machine Learning and Statistical Approaches

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### Abstract

Since last decade research and applications in Data Science has crossed the many milestones. Availability of Data improves the command of the Machine Learning and Artificial Intelligence. It can be applicable to any man made or natural systems, all it needs is the Data that can be tested, managed, classified, processed and compared. There are several computational techniques that can be applied for backward modeling of Environmental Hydro-systems. Efficiency and adequacy of water, supplied from source to various nodes of the Water Distribution Network (WDNs), are prime requirements of system analysis, design and its operation. In this study the statistical approach is used to identify the location of leakage in the distribution network. The Hypothetical model is created to obtain pressure and flow data by simulating a model with known hydraulics and demand in EPANET. Leakage is applied at two locations and for leak detection, multiple locations are observed. Classification is obtained by applying a Machine learning approach. Statistical approach is applied on backward the Probabilistic model to get a possible source of leakage.

**Keywords:** Water Distribution System, Machine Learning, EPANET, Leak detection



Paper ID – 461

## Support Vector Regression and Neural Network Based Predictive Modeling of Evaporation

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### Abstract

In this paper, two data driven approaches namely multilayer perceptron neural network (MLPNN) and support vector regression (SVR) are used to model daily evaporation for a meteorological site located at Navagam, Gujarat India. A stepwise multiple linear regression (MLR) analysis is also performed by considering pan evaporation as dependent variable and maximum temperature, minimum temperature, and wind speed as independent variables. Performance evaluation of these techniques shows that MLPNN model with MAE of 0.977, R<sup>2</sup> of 0.784, MSE of 1.578, RMSE of 1.256 performs better than SVR model with MAE of 0.982, R<sup>2</sup> of 0.760, MSE of 1.759 and RMSE of 1.326. Results show that SVR model performs better than the MLR model.

**Keywords:** Evaporation, Multilayer Perceptron Neural Network, Support Vector Regression, Multiple linear regression

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Paper ID – 474

## Correlating Stream Gauge stations using Multigene Genetic Programming

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### Abstract

Water resources plays a crucial role in the economic development of any nation. The ever rising population and resulting new demands on limited water resources require efficient management of water resources. Stream flow is a measure of the rate at which water is carried by rivers and streams. The traditional stream flow measurement methods are difficult to implement and thus forecasting of stream flow can be proved valuable for water management. In extreme events like flood if we have three stations under consideration and one of them become inaccessible, the technique of correlating stream gauge stations can be beneficial. Correlation means to have a mutual relationship or connection, in which one station affects or depends on another. While correlating two nearby basins although some characteristics may differ from each other but the climate is generally similar and this bond of climate is the key for strong correlation between two stream gauge stations. In the present paper three stations of Godavari river basin namely Ashti, Bhatpalle and Tekra are correlated using Multigene Genetic Programming (MGGP). It gives an equation which can be utilized to predict any missing data of the inaccessible station. There are four combination of models which are developed and further assessed by error measures such as root mean square error, mean absolute error along with correlation coefficient. Ashti to Tekra model and combination of Ashti-Bhatpalle to Tekra model performed with great precision. Correlating work seems to be a promising technique for stations which are in flood-prone localities.

**Keywords:** Stream flow, correlation, multigene genetic programming.

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## Scour depth modelling using gene expression programming

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### Abstract

Scour in a bridge pier is one of the major factors for failure and affects the economy of design. Scouring involves complex physical processes. To estimate the scour depth, a large number of laboratory and field studies have been performed to identify the dominant variables and their relationship. From various literature, the most influencing parameters of scour depth are identified as characteristics of pier, flow and river bed material. The present study emphasizes the gene expression programming (GEP) to estimate the scour depth. Input to the GEP modeling have been taken as flow intensity, densimetric Froude number, gradation coefficient of the bed material, flow shallowness, sediment coarseness and opening ratio. The datasets were collected from previously published various existing research work. Different error analyses were performed to check the strength of the present model. The GEP model with a coefficient of determination greater than 0.80 and mean absolute percentage error less than 15% for the validation stage has a suitable performance for predicting the scour depth for bridge pier.

**Keywords:** Scour depth; Gene expression programming; Pier Scour;

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**THEME – XVI**

**URBAN WATER MANAGEMENT/IRRIGATION  
MANAGEMENT**



Paper ID – 008

## Assessing flow parameters in sand nalla in the vicinity of mouda STPP of NTPC, Maharashtra

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### Abstract

NTPC Limited has set up Super Thermal Power Station at Muda in Nagpur district, Maharashtra. Construction of both stages of the project is over and all the units have been commissioned with Ash dyke for stage-I in function. The construction of Ash dyke stage-II is under progress. Just adjacent to Lagoon-I of 70 acres, Sand Nalla, a tributary of Kanhan River is flowing. The alignment of dyke of Lagoon-I, on left side, at some places, is located very close to Sand Nalla. During the monsoon in 2018, Sand Nalla was flooded due to heavy rainfall in the month of August 2018 in Nagpur district. The flood water of Sand Nalla was temporarily stagnating at Stage-II dyke area and some part of newly constructed dyke was also eroded. 1-D mathematical model studies were conducted using HEC-RAS software by reproducing about 34km reach of Sand Nalla. Water levels and velocities were computed for different ranges of discharges in the river. A very small rise in water level of the order of about 0.21 m was observed due to provision of stage-II Ash dyke. This occurred mainly due to reduction in natural flow area and as result water rushed into a village located on the left. Based on the analysis of results of mathematical model study and observations during the site inspection, a flood protection wall around the affected village with suitable provision to drain rainwater was recommended. The protection measures in the form of stone crates over a suitable synthetic filter were also recommended to the upcoming stage-II ash dyke as well as riverbank wherever agriculture fields were very close to the riverbank to minimize erosion.

**Keywords:** Ash dyke, Bank erosion, Discharge, Lagoon, Protection wall, Stone crate Velocity

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Paper ID – 20

## Design of anti-clogging drip emitter using CT imaging and deep-learning algorithms

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### Abstract

Clogging of drip irrigation emitters is a problem that gradually depletes the discharge from individual emitters and thus uniformity of irrigation water application across the farm land. In groundwater irrigation practice, both physical suspended particles, dissolved chemicals in water and the bacterial growth cause clogging problems during the life of the drip system. In areas where the hardness in groundwater is in excess, the chemical clogging problem is noticed more predominantly. Six drip emitters, which were used by farmers for 3-5 years, were collected from farm lands in Bhongir district, Telangana for this study. These inline emitters, covered by the lateral pipes, were scanned using X-ray Computed Tomography (CT) technique. The 3D images that contain both emitter body of polythene material and clogging deposits were analyzed for the relationship between the geometric parameters of labyrinth flow paths and intensity of clogging. Deep learning U-net algorithm was used to separate and characterize the clogging material of specific density and X-ray attenuation properties from the rest of the emitter body. Curvature of the boundaries, width of flow field of the labyrinth flow paths, width of outlet areas and diameter of the outlets are the four key geometric parameters that influence the clogging intensity. Based on this minute understanding of clogging patterns of cylindrical emitters, a redesign of emitter geometry with improved anti-clogging properties is planned for prototyping and further field testing.



**Keywords:** emitter clogging; CT imaging; anti-clogging design

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Paper ID – 73

### **Numerical investigation of flow around a circular pier in channel confluence with unequal bed level**

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#### **Abstract**

Understanding the flow dynamics around the hydraulic structure caused by complex junction flow is still a major challenge. In order to gain a better understanding of the effect of junction flow and its interaction with structures like circular pier, numerical investigations were conducted at 45° and 90° channel confluences with discordance bed under different conditions. Numerical model was applied to solve three-dimensional RANS equation with RNG  $k - \epsilon$  turbulence closure using the finite volume CFD (SSIIM) model. The fix-lid approach was adopted to capture the air water interface at free surface. Numerical model was validated against results with literature finding. The present study revealed that several parameters like the channel geometry, the hydraulic parameters and presence of structure influence the hydrodynamics of river confluence. The results indicate that the circular pier caused backwater rise by 28% compared to the mixing flow cause at the upstream of main channel for 90° confluence. The present study demonstrate that the separation zone occurs at the downstream corner of the confluence for all flow ratios and attains its minimum value with 45° in contrast to 90° confluence. It is stated that the geometry of the separation zone is function of flow ratio and junction angle. It was noticed that the flow structures and water surface elevation are significantly changed by the circular pier, does not follow the common flow patterns of confluence owing to presence of the pier.

**Keywords:** Channel confluence; Numerical modeling; SSIIM; Circular pier

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Paper ID – 128

### **Selection of The Optimal Design Run-Off Coefficient for Urban Drainage System**

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#### **Abstract**

The design of urban drainage system has been established in Storm Water Manuals and International Standards. The design of storm drainage network is mainly depending upon the Run- off co-efficient, rainfall intensity and return period. The planning and design of new or existing drainage infrastructure should be designed in such a way so that localized flooding and harmful environmental impacts should not be occurred, but it is very difficult to accommodate all parameters in the design. Therefore, the evaluation of design run-off is most important in any drainage scheme. Due to rapid urbanization, increase in impervious, the flooding in Urban areas has become increasingly common in recent decades in India. Almost all cities in India have been developed adjacent to the river in unplanned manner. The run-off co-efficient plays a vital role in run of a catchment. The runoff coefficient has also been calculated over a period 2000 to 2020 and the result shows that built-up area has been increased by 72%. The urban infrastructure development in term of imperviousness level, the cumulative run-off coefficient has been increased from 0.3 in 2000 to 0.36 in 2020. The value of the runoff coefficient arranged in ascending order and plotted on a graph and it shows the strong relationship an increase in runoff coefficient.



The storm water drainage designed for complete development of catchment in term of urbanization by considering the runoff coefficient and return period. In this paper, it has been recommended that the return period should be adjusted with respect to available run-off coefficient so that flooding conditions should not be arises.

**Keyword:** Land use, Urban Development, Runoff coefficient.

Paper ID – 161

## A Study of Greywater Reuse System for an Urban Household

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### Abstract

With the rise in urbanization and simultaneous increase in population, India and the world is facing a problem of water stress situation. So, we must look for conservation and effective utilization of our present water resources like reusing of Greywater. GW is part of sullage water accounting 60-70% of water consumed in urban homes. They are less contaminated, can be reused back in non-portable household activities after treatment. This study brings a sight on an effective and affordable technique of treatment of GW. Focus of the study was on optimization of EC and filtration treatment method coupled with other techniques like magnetic separation. The whole system treatment is automated using micro-controllers. This model proves to have shorter and continuous process time of around 60 minutes. The model requires less foot print, no human intervention and consumes energy of 0.514 kWh/m<sup>3</sup> for reusing 1364 liters of GW by an Indian urban household. The effluent after treatment through EC has removal efficiency of Alkalinity (68.8%), Turbidity (80.3%), TDS (68.96%), BOD (64.5%), COD (68.2%) and bacterial removal efficiency of T.C (91.4%). This effluent after further treatment through filtration can be used for toilet flushing, sprinkling in gardens. The major challenge was determining the size of collection and EC chamber tank and controlling the flow of water continuous without lag. This task of designing is calculated using step algorithm and controlling of flow dynamics is managed by placing pumps, valves and sensors which are controlled by micro-controller. The feasibility and cost analysis of this model have given a positive result.

**Keywords:** Greywater, Electrocoagulation, Tube Settler, Automated control system

Paper ID – 239

## ALIGNMENT OF RRTS RAILWAY BRIDGE ACROSS RIVER YAMUNA FOR DELHI-GHAZIABAD- MEERUT CORRIDOR AT NEW DELHI-A CASE STUDY

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### Abstract

Delhi being a capital city of India has an important strategic, political and ever demanding community role. The city has grown on both the banks of river Yamuna which is basically meandering alluvial river. The river Yamuna flows through highly urbanized corridor of Delhi. Due to continuous growth of the city, the basic need of efficient transportation is a prime issue. With the increasing number of such structures across the river in a relatively short reach length in National Capital Region (NCR) of Delhi, assessment of flooding conditions, back water effect of one structure on other and sediment equilibrium studies using physical model has become one of the essential



requirement. The National Capital Region Transport Corporation (NCRTC), a joint venture Company of Govt. of India and participating State Governments has proposed to connect Delhi with various nodal towns in NCR through eight Regional Rapid Transit System Corridors. Delhi-Ghaziabad-Meerut RRTS corridor is the first corridor which is being taken up for the implementation by NCRTC. Being a high speed, high capacity rail based commuter transit system; RRTS will drastically reduce the travel time between various towns of NCR. However, considering river morphology and minimal disturbance to the river regime, the NCRTC has proposed to convey RRTS bridge alignment entirely over elevated piers across river Yamuna, with distance varies from 418.94 m to 376.50 m from the existing right to left guide bunds upstream of the DND road bridge between existing upstream fixed boundaries of guiding bunds with fixed water way of 636.00 m. The studies were undertaken by CWPRS on existing model of river Yamuna at Delhi. This paper deals with various hydraulic parameters such as optimum span of bridge piers, safe deck level, orientation of bridge axis, afflux on upstream side, maximum expected scour and its back water effect.

**Keywords:** *Waterway, Scour, Afflux, Guide bunds, Embankments etc.*

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Paper ID – 246

### **Optimal Design of Sukla Irrigation Canal**

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#### **Abstract**

Open canals are the major conveyance system for delivering water in most of the irrigation projects. The cost of these irrigation projects mainly depends on the length and cross-section of the open canals. An economic canal section is the one which require the smallest amount of total construction cost. So, the design of open canals should be carried out on optimization basis to determine the minimum construction cost with optimum channel dimensions to deliver the required discharge under uniform flow condition in the canal. The total cost of construction of the canal includes excavation cost and surface lining cost and it is mainly dependent on the channel dimensions. Considering the data of Sukla Irrigation Project, two nonlinear optimization models, one for rectangular channel section and the other for trapezoidal channel section are prepared. The objective function for both the models is the total minimum cost of construction per unit length. The models are then solved in Microsoft excel solver platform considering various constraints to obtain the minimum cost of construction per unit length of the channel and minimum dimensions of cross sections.

**Keywords:** *Canal section Optimization; Sukla Irrigation Project; Microsoft excel solver.*

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Paper ID – 256

### **Issues and Challenges of the Urban Water Supply System in Ethiopia: A Case Study of Dire Dawa**

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#### **Abstract**

Cities around the world are facing critical potable water supply deficits due to population growth, hydroclimatic changes, and urbanization, especially in developing countries like Ethiopia. Although Ethiopia is often referred to as the water tower of Africa, no Ethiopian city receives a 24x7 pipe water supply. Water supply is only for a few hours a day. This study investigates the challenges of the Urban Water Supply System (UWSS) of Ethiopia, particularly in Dire Dawa city, and proposes possible solutions. For this purpose, primary and secondary data were collected from different sources to identify the status of the existing water system. The water utility has been drilling several boreholes to increase the water supply, but still, it has not been able to satisfy the water



requirements at different times. A significant portion of the city (about 23 percent) does not have an adequate water supply. Further, the city water supply system has poor water quality affecting the public health and has several limitations of institutional capacity to build an improved and efficient water supply system. In order to model and simulate the existing water distribution network (WDN), a hydraulic modeling tool (WaterGEMS V8i) along with ArcGIS, is applied. It has been noticed that the WDN has issues related to high pressures in some locations and low velocities in some other parts. In order to manage the WDN effectively, it is recommended to computerize the network so that the various conditions/ stressors can be simulated and analyzed. Further, it is essential to plan and manage the system efficiently and effectively by way of improving the technical capacity of the existing system, and by way of good governance and better water policy.

**Keywords:** *Challenges of urban water; Dire Dawa; Water Distribution Network; Water supply system; WaterGEMS*

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Paper ID – 265

### **Performance Evaluation of Malampuzha Irrigation Project, Kerala**

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#### **Abstract**

Evaluating water use efficiency of irrigation projects are important, keeping in view that many of the irrigation projects in Kerala started during 1950s and 1960s. The study on water use efficiency of Malampuzha Irrigation Project is very important, as Malampuzha is the largest reservoir in Kerala, which caters irrigation water to large area. Malampuzha, commissioned during 1955 has a culturable command area of 22554 ha. The overall efficiency of the irrigation project is estimated as the product of the four efficiencies, reservoir-filling efficiency, conveyance efficiency, on farm application efficiency and drainage efficiency, as per the guidelines of Central Water Commission. Reservoir Filling Efficiency is estimated as the ratio of maximum live storage attained in the reservoir in a particular year to the design live storage of the reservoir. Conveyance efficiency is defined as the ratio of water delivery at the inlet to the block of fields to water released at the project head works. On-farm application-efficiency is the ratio of the crop water requirement for various crops for which the project provides water for various crops from the outlets of canal system. Drainage Efficiency is a measure of the amount of water draining from the root zone actually collected and discharged by the drains. Reservoir efficiency is estimated from the reservoir operation data, inflow estimated using inflow-outflow method. For conveyance efficiency, intense field survey was conducted to measure velocity and cross section of canals for about 10% of the total length of the canals. On farm application efficiency consists of two parts; conveyance efficiency of field channels and on field water application efficiency, which account for the loss from the field by deep percolation and leaching. When compared with the landuse map of different area, it was found that some paddy area is converted to urban and plantation crops. This study gives the four efficiency separately, so that suggestions can be made for improving the efficiency more accurately.

**Keywords:** *Water use efficiency, irrigation project, conveyance loss, Malampuzha*

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## Evolutionary Optimization Techniques for Optimal Design of Water Distribution Networks

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### Abstract

The design of water distribution networks (WDN) is familiar as a non-deterministic polynomial-time hard problem. To handle such problems effortlessly, the optimization tool with both the exploration and exploitation features is a primary requisite. In the present study, an efficient and effective optimization tool, the Genetic algorithm (GA) is considered. Different variants of GA are formulated considering three different selection mechanisms and by incorporating an elitism operator to these models. The working mechanism of GA variants is demonstrated considering the well-established WDN benchmark problem, Blacksburg Network (BLN). From the results of the analysis, it is observed that all the GA variants are efficient in converging to the feasible optimal solutions for BLN. Especially, the GA models with the truncation and tournament selection mechanisms are successful in converging to an optimal solution which is consistent with the results reported in the literature. When the number of successful trials out of 50 is considered, the GA variants are found to be less robust with only a maximum of three successful trials. Though all the GA variants considered in the study are efficient in exploiting the existing information with the parent chromosomes, GA is found to be less diversified. Considering the results of the present study, we suggest, any improvement that enhances the exploration capabilities of GA is futuristic.

**Keywords:** Exploitation; Exploration; Genetic Algorithm; Selection mechanism; Water distribution Network

## Estimation of Potential Evapotranspiration in command area of New Mutha Right Bank Canal, Pune, Maharashtra, India

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### Abstract

Potential evapotranspiration (PET) signifies the combined loss of water through transpiration and evaporation of water from the earth surface. The PET is dependent on weather parameters like temperature, humidity gradient, sunlight, and wind velocity. The estimation of Potential Evapotranspiration (PET) is important for prediction of water balance of the basin and estimation of net irrigation requirement for crops in the command areas. In the present study, well known Modified penman method has been used to compute the reference evapotranspiration (E<sub>Tr</sub>) for a canal command area new Mutha Right Bank Canal, Pune, Maharashtra, India. Apart from above, five other methods are also used to compute the PET of the same command area. The performance of other five method, which are less data intensive, are compared with standard Modified Penman Method. The other methods, namely, Penman Monteith Method, Hargreaves Samani Method, Priestly Taylor Method, FAO Radiation Method,



Pan Evaporation Method and Hargreaves Samani Methods have given more potential evapotranspiration vis-à-vis other methods. The spatial distribution of PET in the command area using Modified Penman method has been prepared using ARC GIS 10.3 software. The weighted average PET for the whole command area has been found to be maximum i.e. 5.21 mm/day in the month of May and minimum i.e. 2.77 mm/day in the month of December using Modified Penman's method. Apart from this Hargreaves Samani Method has shown extreme value with respect to the other methods i.e. 6.43 mm/day in the month of April and 2.77 mm/day as lowest value in the month of December.

**Keywords:** Potential evapotranspiration, New Mutha Right Bank canal, Modified Penman Method

Paper ID – 290

### Modal analysis for a water carrying piping system

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#### Abstract

Modal analysis is a simple way to calculate the natural frequencies of any system so as to identify the fundamental frequency (most dangerous frequency) of the system. The natural frequencies depend on the geometry and constraints of the system. When the frequency of vibration of the system matches the fundamental frequency, the amplitude of vibration increases drastically, leading to the failure of the structure. When an exposed water-carrying conduit vibrates between two supports in its fundamental frequency, the system may lead to failure due to excessive deformation. The current study analyses the behaviour of the pipe under different anchoring conditions. The modal analysis is conducted under two conditions: pipe empty condition and pipe running full of water. The natural frequency and mode shapes are determined up to 20 modes, as the alternate modes are the same in two lateral directions. The natural frequency was found to get decreased by the presence of water inside, but the mode shapes remain unaltered.

**Keywords:** Modal analysis; water carrying system; natural frequency

Paper ID – 292

### Water Urbanism: Strategies for stormwater management through rainfall-runoff analysis using SCS-CN method and GIS in watersheds of Ajmer, Rajasthan

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#### Abstract

The ancient settlements grew ensuring the concerns of the regional water systems since beginning of human civilization. In recent times the cities expanded through planning mechanisms like Development Plans, that accommodates rapid growth of population and economic needs often ignoring the hydrological dynamics of the region. As a result, water scarcity or urban flooding are the most common impacts of urbanization and land use changes being observed in and around the cities. As the cities are expanding, there is continuous pressure on water resources. In the context of water scarce regions, the efficient system for water harvesting, storage, use conservation, management and regulation systems are necessary for survival and growth of the cities. Many traditional Indian cities including Jaipur, Jodhpur, Ajmer, Bundi etc. during the medieval times demonstrate the



use of efficient water management methods at city scale. In spite of the rich history of water management, with the current demographic, urbanization trends and loss of local water sources, scarcity of water; can have disrupting influence on their economic growth, social harmony, and liveability. Thus, it is essential to find strategies to ensure that the cities are resilient to the challenges of water scarcity, droughts and floods; making the transitioning of cities more urgent. The current Global concepts of Water-sensitive Urban Design (WSUD), Sustainable Drainage Systems (SuDS), Green Infrastructure (GI), Integrated Urban water Management (IUWM) etc. are being taken up by many Indian cities at various levels to conserve, preserve and manage their water resources through planning. This study attempts to demonstrate strategies for stormwater management through rainfall-runoff analysis based on the natural water regime especially for the cities falling in the water scarce region. The city of Ajmer, falls under the water-scarce region of Rajasthan, to the east of Aravalli ranges, receiving unpredictable rainfall. It also faces challenges of water shortage and urban flooding. The total area covered for the study is 767 sq.km, which falls within three river basins, such as, Sekhawati river basin in the north, Luni river basin in the west and Banas in the east. Six watersheds are identified within the study area using DEM file from USGS website in ArcGIS and the widely used method of surface runoff, i.e., SCS-CN is applied to calculate the watershed-wise surface runoff volume. Finally, strategies are identified for every watershed to conserve as well as preserve the surface water-runoff for fulfilling the non-domestic needs of water in the city.

**Keywords:** *urbanization; water-scarce regions; rainfall-runoff analysis; stormwater management; hydrologic modelling*

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Paper ID – 309

## **TRANSIENT ANALYSIS FOR WATER SUPPLY PIPELINE FOR POKARAN VILLAGES**

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### **Abstract**

The sudden stoppage of pumps often cause alternating high pressure changes in long water supply pipelines, which result in back flow, negative pressures, column separation and excessively high pressures in pipelines. The resulting pressure variation may lead to damage of piping system. Transient analysis is essential to verify design and operation of piping systems and to determine maximum and minimum pressures acting on pipeline at various time intervals along the pipeline to prevent damage. Based on the transient analysis anti surge devices are installed at optimized locations on rising mains to protect the pipeline against surge pressures. This paper presents a transient analysis based on method of characteristics for water supply project of public health engineering department, Jodhpur, Rajasthan. It envisages drawing of water from Indira Gandhi Main Canal for drinking water supply to 106 villages of Jaisalmer district. The provision of anti-surge devices like air vessels, zero velocity valves, one way surge tank for this project are considered to be uneconomical for smaller diameter pipelines with small flow rate. Hence, it was considered to provide air valves alone for safeguarding system components against surge pressures due to power failure of pumps. Studies were conducted to optimize number of air valves and their location on rising main for each pumping scheme. The results showed that provision of air valves alone for all the rising mains at different chainages of the pumping schemes mitigated the water hammer pressures.

**Keywords:** *Water hammer; anti surge devices; maximum pressure; minimum pressure*

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Paper ID – 319

## Block level Livelihood Vulnerability Index of a Himalayan district in Upper Ganga Basin

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### Abstract

Managing climate change induced vulnerability is a challenge in the Himalayan region. The policy interventions are often not targeted due to lack of assessment and prioritization of vulnerable areas of a district/state. The intervention measures already available in the Uttarakhand Himalaya are limited due to want of huge investment and unfavorable terrain. Vulnerability must be understood as a set of socioeconomic conditions that are identifiable in relation to climate change which include natural disaster, demography, water, health, livelihood, social network, food. Combination of these factors at varying level of dominance is driving the vulnerability of a region. Therefore, identifying and grading the key factors influencing the regions vulnerability can of great help in strategizing targeted adaptive measures. The dynamic nature of climate change vulnerability depends upon both biophysical and social processes. We undertook the study at three blocks in the Rudraprayag district in the Upper Ganga Basin (UGB) using the IPCC's Livelihood Vulnerability Index (LVI) approach. LVI assess the quantum of adaptive capacity, sensitivity and exposure of a region. The LVI ranges from -1 to +1 representing low to high vulnerability. To assess the vulnerability in terms of exposure, sensitivity, and adaptive capacity, 7 major indicators and 25 sub-indicators have been considered in the study. The information for the 25 sub-indicators were drawn from questionnaire-based field survey conducted in three blocks viz. Augustmuni, Jakholi, and Ukhimath comprising of 39 villages and 128 households. The LVI values stand at 0.07, -0.18, and -0.21 for Jakholi, Ukhimath, and Augustmuni blocks respectively. The LVI values indicated that Jakholi block is highly vulnerable followed by Ukhimath and Augustmuni blocks. It has also been noted that Jakholi block is highly exposed (0.58) to climate change variability coupled with lower adaptive capacity (0.42). The exposure and adaptive capacity of Augustmuni block stands at 0.23 and 0.69. Ukhimath block although indicated a higher adaptive capacity (0.82). The sensitivity of the three blocks is more or less same. It is recommended that any adaptive measures initiated in the district should be prioritized to Jakholi block followed by Ukhimath and Augustmuni.

**Keywords:** Livelihood Vulnerability Index; Upper Ganga Basin; Prioritization; Climate adaptation

Paper ID – 355

## Insight into the key model parameters of Pore Network affecting SWRC simulation

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### Abstract

Efficient management and simulations of many near-surfaces hydrological processes such as groundwater recharge, runoff, infiltration, irrigation, optimal water use in agricultural operations, and contaminant transport in the vadose zone require reliable and well-engineered estimates of the unsaturated soil hydraulic properties. Most significant being the soil water retention curve which relates capillary pressure (matric suction) and fluid saturation, and the unsaturated soil hydraulic conductivity function. SWRC is one of the fundamental characteristics of unsaturated soils and many basic properties of unsaturated soils such as volume change behavior, coefficient of permeability, and shear strength are closely related to it. The experimental determination of SWRC



is a very laborious and time-consuming task so giving rise to numerical schemes and simulations tools which can estimate the retention behavior of soil at different mechanical and hydraulic conditions. One of the newly introduced simulation techniques for two-phase flow in porous media is pore network modelling. Pore network models mimic the porous structure of soil and can, therefore, be considered as powerful physically-based models. In this study, pore network model is used to simulate SWRC and the effect of various structural parameters of the proposed pore network model such as coordination number, aspect ratio, and pore size distribution parameters on correct simulation of SWRC is studied.

**Keywords:** SWRC; Porous media; Pore network modelling

Paper ID – 382

## Comparison of soil water movement models with experimental observations in agricultural fields

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### Abstract

Understanding the relationships between plant, soil and water is essential for integrated agricultural water management. The natural variability exhibited by soil hydraulic properties poses severe challenges to model water movement through porous formations in cropped fields. A nonlinear root water uptake model coupled with 1D and 3D Richards Equation is used to simulate soil moisture dynamics. Soil hydraulic parameters were collected at 10 cm depth and soil moisture was measured by capacitance-based soil moisture sensors at different depths. The purpose of this study is to evaluate the performance of different soil moisture simulation models (Num-1DST, Num-1D, and Num-3D) for simulating soil moisture under field conditions for wheat crop in the Indo-Gangetic Plains. Observed soil moisture values are compared with simulated data using statistical indices such as coefficient of determination ( $R^2$ ), root mean square error (RMSE), and the normalized root mean square error (NRMSE).

**Keywords:** soil moisture, cropped fields, numerical simulation, Richards Equation

Paper ID – 454

## Traditional stormwater management system in watershed of wetland, a study and overview of “Dong” systems in wetland fringe villages of Assam

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### Abstract

Storm water management is the process of dealing with rainwater for a better habitable space in a best possible way. This process is essential whether it is a flood prone area or a drought prone area. An intelligent drainage system is required to ensure the current amount of water to exit either as runoff or Sub surface infiltration into the ground. A good storm water drainage system should be enforced to prevent flood like situations when there is a condition with maximum rainfall in monsoons and water table rises to ground. The state of Assam receives more than 2000 mm rainfall annually and 80% of rainfall in monsoons causing 9% of total area getting submerged. While managing stormwater it is very crucial to recognize and assess the amount of water that flows as surface runoff, groundwater infiltration and evaporation. While in special conditions where the daylight hours reduced to average 4.8 hours from 12 hours of daylight per day in monsoon the expected evaporation rate is comparatively very slow. The soil is sandy clay and the infiltration rate is very less in flatter slopes. In such cases the only way to manage storm water is a significant surface drainage system with combination of Sheet and Channel flow. This crucial condition is being manipulated by traditional people with their traditional knowledge system and practices passing through generations with observation and experimentation. This paper will discuss about how the rural



Assam villages use traditional practices of stormwater drainage system with a series of “Khaal and Dongs” through the entire settlement exiting them to nearby waterbody, as one can say wetlands are the sponges to refrain from flood like situations. This case study of villages in fringe areas of Sorbhog Beel wetlands with detail study of parameters considered in the system deriving successful runoff of water hence preventing flood in wetland upland areas. This study has been done to contribute in future research of traditional knowledge of pertaining a good storm water management system through drainage system in watershed area.

**Keywords:** *Traditional System, Stormwater management, Watershed, Drainage, Runoff, swale.*

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Paper ID – 489

## Drought modelling by using artificial neural network

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### Abstract

Agriculture is the backbone of India which heavily depends on the change of climate in the country. A prolonged period of abnormally low rainfall, leading to a drought. Drought in India has resulted in tens of millions of deaths over the last three decades. Also, it becomes a big challenge to water resources, for the best water resource management drought forecasting is a must. As drought is a nonlinear parameter Artificial neural network(ANN) which is inspired by the human brain will be a good option to use. Drought indices that measure the degree of dryness can be calculated in ANN by Neural network type is feed-forward backpropagation algorithm and training with levenberg-Marquardt(LM) backpropagation algorithm for the selected study area. Here an attempt can be done to compare the results of actual and model output values and predict the efficient projection of drought.

**Keywords:** *Drought, ANN, feed forward back propagation, LM backpropagation*

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Paper ID – 493

## Optimal Design of Sewerage System including Pumping Cost at STP using MPSO

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### Abstract

Optimization of sewerage system design has been a current research area. For different alternative designs of a layout, the invert level of last sewer may be different, requiring different depths of sump well and consequently pumping cost at the sewage treatment plant (STP) would be different. The objective function normally chosen for minimization of cost of sewerage system is without including pumping cost at the STP. In this paper the optimization of cost of sewerage system has been attempted including pumping cost at STP. This paper compares two types of problem by a case study of Fatehpur sewerage system in District Sikar, State Rajasthan, India. First



one (Type I) is the optimization of sewerage network with pumping cost at STP included in the objective function and the second one (Type II) is optimization of the cost of sewerage network without including pumping cost at STP in the objective function and adding the pumping cost at STP to optimized cost to get the total cost. The optimization method used is Modified Particle Swarm Optimization (MPSO). Comparison of these problems indicates that the Type I objective function gives about 0.2% less cost than the Type II for the problem selected.

**Keywords:** *Optimization, Sewerage System, PSO, Pumping*

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**THEME – XVII**  
**WATERSHED MANAGEMENT**



## Variability analysis of hydrological parameters of Faridabad district (Haryana state)

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### Abstract

Hydro-geological parameters and land-use pattern of any region vary with space & time and have a profound impact on the groundwater resource of any region. Faridabad district, an industrial town of Haryana state is situated in south eastern part of Haryana and is a part of National Capital Region (Delhi-NCR) has been considered in this study. Some regions in Faridabad district have undergone ground water level declination recently and this pressure is attributed to ground water being the principal resource for irrigation in this district. The monthly and meteorological data for 37 years ranging from 1981-2018 was collected from the NASA website and later on it was arranged season wise namely monsoon, pre monsoon, post monsoon rabi (POMR) and post monsoon kharif (POMK). The ground water level data for 17 years (2000-2017) was accessed through CGWB website. In this paper, an attempt has been made to analyse seasonal trends of hydrological parameters of the region including Precipitation, Temperature at 2m, Wind Speed at 2m and Relative Humidity at 2m along with ground water levels by using Mann-Kendall test and Sen's slope estimation techniques on the basis of MAKESENS excel template. The mean & standard deviation values of the hydrological parameters along with Mann Kendel test static 'Z' and Sen's slope 'Q' have been calculated and subsequently graphs are plotted for the purpose of trend analysis. It is expected that results of this study can be implemented for water availability studies in any region with similar climatic conditions for management of water resources at local and regional level.

**Keywords:** Rainfall, Ground Water, Trend analysis, Hydrological parameters, Mann-Kendall Test, Faridabad.

## Comparison of spatial interpolation methods for filling missing observations in daily rainfall data

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### Abstract

Precipitation data is one of the main inputs for water-related research. However, there exists gaps (missing values) in the observed data series due to various reasons. To fill the missing observations in rainfall data, different spatial interpolation methods are available. Spatial interpolation techniques are also suitable in obtaining the spatial distribution of precipitation in areas where a sufficient number of rainguage stations are not available or the available stations are not evenly distributed. The current study involves the identification of the best method of spatial interpolation among four different interpolation methods, amounting to twelve different interpolation schemes in estimating missing rainfall data. In this study, the Koyna river basin located at Maharashtra, India was selected as a typical region. The performance of different methods in estimating the daily precipitation of the region was evaluated through a set of three error measures, Mean Bias Error (MBE), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) and using a cross-validation procedure. The comparative study demonstrated that the choice of different interpolation method yields significantly different results. Out of the twelve methods analyzed, Kriging with spherical variogram was found to provide best results with MBE, MAE



and RMSE values as -4.06 mm, 2.67 mm and 8.33 mm respectively. The other methods that were found to perform reasonably well were Kriging with exponential and circular variograms, trend surface of degree  $n = 1$  etc.

**Keywords:** *Rainfall Data; Missing Observations; Spatial Interpolation*

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Paper ID – 133

## **An Environment Concerned Risk Based Approach for Evaluating Watershed Health**

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### **Abstract**

Evaluating the health of a watershed helps water managers and planners in prioritizing zones to formulate proper plans and efficient management strategies for ensuring sustainable water management. Yet, it has not attracted the attention of researchers, especially in developing countries. Also, the environmental flow concept has not been considered till now for assessing the health status of a river basin. To address these limitations, the present study was carried out in Rushikulya River Basin, a sub-tropical humid river basin of Eastern India. For assessing the health of the study area, two meteorological and hydrological criteria, viz., ‘standardized precipitation index’ (SPI), and ‘monthly streamflow’ for the period of 1990-2016 were selected. SPI of the whole basin was calculated at a monthly time scale. Further, three risk-based indicators, i.e., reliability, resilience, and vulnerability were calculated and combined to develop an ‘integrated watershed health indicator’. In the context of SPI, the threshold value was taken as that obtained for ‘normal’ condition, while ‘monthly environmental flow’ was considered as the threshold for streamflow to assess the health of the river basin from a hydrological point of view. The environmental flow was calculated by Flow Duration Curve Shifting (FDCS) technique that requires natural streamflow as its input. As historical natural streamflow is not available in the river basin, it was simulated from a previously calibrated hydrological model for the area. Based on ‘SPI’, the related reliability and resilience of the whole river basin are found to be decreasing over the years with an increased vulnerability. However, the risk indicators corresponding to ‘monthly streamflow’ show an insignificant increasing trend over the years. The analysis revealed that the overall basin health was found to be in the ‘worst state’ for 11 years, while it was in the ‘good state’ for six years. The methodology adopted and the results obtained in this study can provide the water managers and decision makers a practical idea of the overall health status of a river basin from an ecohydrological context for developing an efficient water management plan.

**Keywords:** *Integrated watershed health indicator; risk-based indicators; environmental flow; FDCS; SPI.*

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Paper ID – 169

## **Surface Water Balance Study of River Sarada**

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### **Abstract**

The Inter-basin water transfer, proposed in India, for transfer of water from a surplus river basin to adjacent deficit river basins, in the monsoon months of a year needs Water Balance Study of the donor river basin to be done. The



surplus or deficit of a basin is decided based on the Water Balance Study of the basin, by taking into account the observed discharge data, upstream utilization, import & export, existing & future needs for irrigation, domestic, industrial, hydropower uses & regeneration, etc. The water availability studies are to be carried out in two parts viz., surface water availability and ground water availability. The surface water availability studies are to be carried out sub-basin wise and at diversion points. The necessary input data may be rainfall data, observed discharge data, upstream utilization, import and export of water, etc., needed to work out the dependable yields and to bring out the diversion proposals, accordingly. The Surface Water Balance study of the river *Sarada* in *Andhra Pradesh* is carried out basing on the gauge discharge data of the river and its water utilization. In due course of the study, the daily discharge data, missing over a period of 28 years from 1989-2017 despite availability of gauge data, was filled/ completed. The Surface Water Balance of the river *Sarada* on completion of the filled discharge is observed to be surplus, based on the water year approach.

**Keywords:** *Sarada river, Gauge Discharge data, missing discharge data filling, Surface Water Balance study.*

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Paper ID – 181

## **Analysing the Response of Meteorological Droughts on Stream Flow in the Pennar River Basin**

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### **Abstract**

Meteorological drought is a natural calamity characterized by lack of precipitation for a longer time period. The onset of drought occurs from the first category and evolves into other categories in the following manner: Meteorological, Agricultural, Hydrological and Socio-economic. In simpler terms, the meteorological drought propagates into other aspects of hydrological regimen such as soil moisture, groundwater, and stream flow. Is there any pathway by which it propagates? Does a strong relationship exist between meteorological drought and other parameters? These are the questions researchers are trying to answer globally. The response of basin towards meteorological drought may vary for different climatic zones, so in the present study, an attempt has been made to study the impact of meteorological droughts on hydrological regime of Pennar River basin located in India. The meteorological drought is identified and characterized using advanced meteorological drought index, Standardized Precipitation- Evapotranspiration Index (SPEI). The daily gridded meteorological data obtained from India Meteorological Department was used to estimate SPEI for the period 1988 to 2018. To assess the impact of meteorological drought on stream flow of Pennar Basin, hydrological modelling using the Variable Infiltration Capacity (VIC) model was employed to compute discharge at the outlet of the basin. The validation of hydrological model was done with the observed discharge values at the outlet obtained from India-Water Resources Information System (India-WRIS; <https://indiawris.gov.in/wris>). The impact of meteorological drought on discharge of the Pennar River was analyzed by estimating Standardized Runoff Index (SRI) on a monthly time scale and correlating the SRI with SPEI for different drought events occurred in the basin during year 2008 to 2018. It was observed that the discharge values were lower for the drought hit periods when compared with normal periods. The impact of meteorological drought on stream flow appeared to vary with combination of severity, persistence, coverage and location of drought occurrence. The present attempt of using hydrological model for assessment of impact of meteorological drought on hydrological regime of a basin enabled the possibility of analyzing hydrological droughts, caused due to meteorological drought, at unengaged parts of the basin as well.

**Keywords:** *Meteorological drought; Variable Infiltration Capacity model, SPEI, SRI, SPI*

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## Estimation of Peak Flood Discharge for Ungauged Catchments by Hydrometeorological Approaches

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### Abstract

Estimation of Peak Flood Discharge (PFD) for ungauged catchments is required in hydrological practices and also one of the important parameters for design of hydraulic structures, river protection works, development of integrated water resources management projects, etc. This can be achieved by adopting hydrometeorological approaches such as flood frequency analysis, rational formula, envelope curves and Synthetic Unit Hydrograph (SUH) method. In this paper, as the catchments of the study area are ungauged, PFD is estimated by using rational formula for the catchments with catchment area less than 25 km<sup>2</sup> and SUH method for the catchments with catchment area more than 25 km<sup>2</sup>. For both rational formula and SUH method, rainfall depth becomes an important parameter, which can be estimated through extreme value analysis by fitting of Gumbel distribution to the Annual Maximum Series (AMS) of rainfall data. Parameters of the distribution are determined by maximum likelihood method and used for estimation of rainfall. Goodness-of-Fit tests viz., Anderson-Darling and Kolmogorov-Smirnov are applied for checking the adequacy of fitting Gumbel distribution to the AMS of rainfall data. The paper illustrates the procedures adopted in estimation of PFD for the ungauged catchments of Suketi Khad by hydrometeorological approaches, and the results obtained thereof.

**Keywords:** Extreme value analysis; Gumbel distribution; Maximum likelihood method; Peak flood discharge; Rational formula; Synthetic unit hydrograph

## FLOOD ROUTING IN A RIVER BY MODIFIED PUL'S METHOD

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### Abstract

Flood Routing is the technique of determining the Flood Hydrograph at a section of a river by utilizing the data of flood flow of one or more upstream sections. The hydrologic analysis of problems such as flood protection, flood forecasting, reservoir design and spillway design usually include flood routing. The flood flow in a river is basically a Gradually Varied Unsteady Flow (GVUF). The inflow hydrograph used can be applied for different flood events by adjusting its parameters accordingly. Hydrologic Routing is performed here by using Modified Pul's Method /Level Pool Method by considering a problem statement. It is based on continuity equation. HEC -HMS software is used to simulate the routing process on Kol Dam, Himachal Pradesh where the inflow hydrograph is taken on Sutlej River. The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic drainage basins. HEC-HMS is a product of the US Army Corps of engineer's research and development program and is produced by the Hydrologic Engineering center (HEC). HEC-HMS simulates Precipitation-Runoff and routing processes both natural and controlled. It includes many hydrologic analysis procedures such as event infiltration, unit hydrographs, and hydrologic routing. The attenuation and lag can also be observed by this software. The



software features a completely integrated work environment including a database, data entry utilities, computation engine, and results reporting tools. A graphical user interface allows the user seamless movement between the different parts of the software. Simulation results are stored in HEC-DSS (Data Storage System) and can be used in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

**Keywords:** *flood protection, flood forecasting, reservoir design and spillway design, HEC- HMS, attenuation, lag, GVUF, Modified Pul's Method, Floodplain regulation, systems operations*

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Paper ID – 276

## **Wastewater Management through Water Drainage System: A Case Study**

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### **Abstract**

Wastewater drainage and its treatment prevails as one of the major contemporary problems in urban areas. The growing infrastructure constantly accrues stress on the already present wastewater drainage and treatment systems. One of the major problems has been the waterlogging of regions because of improper drainage. This problem worsens due to rainwater runoff in the low-lying area during the rainy season. This paper aims at developing a holistic methodology to cater the problems caused by ineffective drainage system by designing a drainage and treatment system for Dr BR Ambedkar National Institute of Technology, Jalandhar. Rainfall pattern has been studied for the place to ensure the effectiveness of the drainage system during the peak stress. Sanitary wastewater and Stormwater runoff have both been taken into consideration to calculate the effective diameter of drainpipe and other important parameters. The study also suggests the use of Moving Bed Biofilm Reactor (MBBR) over other types of treatment plants through suitable comparison. Wastewater consists of a dynamic mixture of the contaminant in different environments; however, it can be treated similarly for institutions similar to that in the case study.

**Keywords:** *Drainage; MBBR; rainwater; wastewater; sewage*

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Paper ID – 317

## **River discharge estimation using SARIMA model and OLS regression from satellite altimetry data –A case study of Amazon River**

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### **Abstract**

River discharge estimation has a vital role in infrastructure planning, flood mitigation. However, the number of stream gauges is decreasing globally, which is seen significantly in developing countries, which made streamflow estimation difficult. Here we propose a Seasonal Autoregressive Integrated Moving Average (SARIMA) time series model, which can be a potential alternative for conventional methods such as hydraulic modeling, velocity-



area method, etc. for discharge estimation. The present study demonstrates the use of the SARIMA model for long term river discharge (2007-2011) forecast with (1971-2011) discharge data at the Fazenda Vista Alegre station in the Amazon river. The Relative Root-Mean-Square Error (RRMSE), Relative Root-Mean-Absolute Error (RRMAE), and coefficient of determination ( $R^2$ ) values of the model are 0.154, 0.120, and 0.89, respectively. For poorly gauged rivers, discharge can be estimated from the satellite altimetry water level. Here Optimized Least-Square (OLS) regression is used to obtain best-fit values for the relation between water level (H) and Discharge (Q) from the Envisat (RA-2) altimetry water level observations. This analysis shows the potential of altimeter data in a poorly gauged river basin as its regression equation can help quantify discharge only using altimeter data. The RRMSE, RRMAE, and  $R^2$  values of regression are 0.261, 0.297, and 0.83. The result shows that the SARIMA model produced estimated Q shows good prediction fitting and can be used for long-term forecasting. Whereas for the poorly gauged river, the discharge estimation from satellite altimetry data shows good prediction and can be employed for discharge estimation.

**Keywords:** Discharge estimation, SARIMA Model, Satellite Altimeter, OLS regression, Amazon river

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Paper ID – 390

## **Distribution, Trend, and Concurrence of Meteorological, Hydrological and Agricultural Droughts over Madhya Pradesh, India**

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### **Abstract**

Drought assessment is crucial to mitigate its adverse impact, especially in areas where risk is more due to changing climate. However, most of the studies deal with one or a couple of droughts and the absence of integration of meteorological, hydrological, and agricultural droughts in terms of frequency, concurrence, and evolution process, especially in Madhya Pradesh. In this study, we estimate the meteorological, hydrological, soil moisture, and vegetation droughts over Madhya Pradesh using the standardized precipitation index (SPI), standardized runoff index (SRI), standardized soil moisture index (SSI) and vegetation drought index (VCI) during the period 1982-2013 respectively. The study investigates the spatio-temporal distribution of droughts, individually and concurrently. Further, drought trend analysis is carried out in terms of their extent, duration, and frequency. Finally, we proposed a decentralized Blockchain-based disaster management framework to enhance and improve the existing drought management system and facilitates the disaster victims to get their relief as fast as possible. Examinations indicate that soil moisture and hydrological droughts are more extreme related to other drought types over Madhya Pradesh. Moreover, 90% of concurrent droughts include soil moisture drought as a major part. This study facilitates a comprehensive approach to better understand the dynamic characteristics of all major droughts and their complex interaction from various perspectives over Madhya Pradesh, and thus provides useful insights for policymakers to develop effective strategies for drought mitigation and sustainable ecosystem management in the state.

**Keywords:** Drought Concurrence, Drought Evolution, Drought Extent, Drought Severity.

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**THEME-XVIII**

**HYDRODYNAMICS AND RIVER ENGINEERING**



Paper Id-004

## Experimental study of dam pipe outlet stilling basin models using two baffle walls

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### Abstract

Stilling basins can be used effectively in dissipating the excessive energy downstream of hydraulic structure like over flow spillway, sluices, dam pipe outlets, etc. This paper describes about the experimental work for the development of new stilling basin model for dam pipe outlet using two baffle walls one after another in the front of issuing jet along with end sill. On the basis of present investigations, newly developed stilling basin model has been compared with USBR VI stilling basin model. The main purpose of this paper is to design and develop new model for pipe outlet stilling basin which is more efficient as compared to other model for pipe outlet by developing new physical models of stilling basin in the laboratory with the help of suitable appurtenances. The new models were tested for two Froude numbers (namely  $Fr = 2.85$  and  $3.85$ ) and compared to USBR VI stilling basin model recommended for the pipe outlet. The scour parameters were measured for each test run and flow pattern was also observed. The performance of the models was evaluated by performance number (PN). After experimental study, it is found that, for tested Froude numbers by using two baffle walls along with end sill, the performance of stilling basin model improved significantly as compared to USBR VI stilling basin model for a given flow conditions.

**Keywords:** Baffle wall, Froude number, Hydraulic structure. Performance number

Paper Id-013

## Effect of Climate Change on Future Reference Evapotranspiration ( $ET_0$ ) in Vidisha district of Madhya Pradesh

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### Abstract

Climate change scenarios with a high spatial and temporal resolution are required in the evaluation of the effects of climate change on water resources and agricultural potential. In the present study, GCM CAN ESM2 was employed to generate the future climatic data under RCP scenarios 2.6 and 8.5 for Vidisha district of Madhya Pradesh. The Vidisha district lies at  $23.5251^\circ\text{N}$  and  $77.8081^\circ\text{E}$  covering an area of  $7371 \text{ km}^2$ . The FAO CROPWAT tool was utilized to estimate the future total reference evapotranspiration for years 2030, 2060 and 2090. In this region, the  $ET_0$  values for RCP 2.6 were found to be in the range of  $394.5 - 510 \text{ mm}$  for years 2030, 2060, 2090. While the  $ET_0$  for RCP 8.5 was found out to be  $436 - 710 \text{ mm}$  for years 2030, 2060, 2090 respectively. It is seen that there is maximum variation in the  $ET_0$  values under RCP 8.5 climate scenario. The RCP scenario 8.5 is the worst-case scenario in which the water requirement is surely increasing in the future. The results of this work can be utilized for proper irrigation scheduling and thereby reducing the agricultural risks due to climate change.

**Keywords:** Climate Change, CANESM2, CROPWAT, Evapotranspiration



Paper Id-015

## Assessment of Revised Capacity of Tawa Reservoir using QGIS tool

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### Abstract

A reservoir is an important part of water resource system. In present era, reservoir sedimentation is a vital problem which causes loss in their storage capacity potential because of silt load for short or long period of time. Periodic assessment of the sediment deposition pattern, evaluation of available storage capacity of reservoirs, irrigation canal, hydropower systems should be taken as basic importance for water resources planning and land & water management system. By use of remote sensing image data in combination with a quantum geographic information system (QGIS), the temporal change in water-spread area can be analysed to evaluate the total deposition of sediment is 342.71 MCM, sedimentation rate is 7.53 MCM per year and percentage loss of capacity is 17.19% from 1975 to 2019 in Tawa reservoir situated in the year 1974 in Hosangabad district, Madhya Pradesh state, India. The QGIS tool provided efficient results in assessment of the reservoir revised capacity.

**Keywords:** NDWI, QGIS, Reservoir Siltation, Revised Capacity, Water Spread Area

Paper Id-018

## Simulation of Rainfall Runoff using HEC-HMS Model for Bah River Basin of Vidisha Region in Central India

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### Abstract

Hydrological modeling is a commonly used tool to estimate the basin's hydrological response due to precipitation. Present thesis work aims to calibrate and validate HEC-HMS rainfall runoff model for Bah river basin at Ganjbasod discharge measurement site in Vidisha district. The sub-catchment area of Bah river with its outlet at Ganjbasoda is 564.047 km<sup>2</sup> which lies between the 23°30'00" N latitude to 23°54'30" N latitude and 77°17'00" E longitude to 77°35'30" E longitude. HEC-HMS uses separate mathematical models to represent each component of the runoff process, for runoff volume SCS Unit hydrograph and for routing Lag model was used. The model was calibrated and validated at Ganjbasoda using for three years, 2004, 2008 and 2012 Based on the soil classification, the given area falls under the soil; groups D with soil moisture condition of AMC-II The result from the model is compared with the observed discharge and performance of the model is measured using five performance indices. The results shows that curve number is a sensitive parameter for watershed. For the calibration year 2004 (R<sup>2</sup>= 0.776, NSE=0.754, RMSE=49.13, MAE=17.07, Pdv=34.43%) and for the validation year 2008 (R<sup>2</sup>= 0.687, NSE=0.712, RMSE=54.90, MAE=15.76, Pdv=26.88%) and for 2012 (R<sup>2</sup>=0.819, NSE=0.790, RMSE=78.66, MAE=20.60, Pdv=8.57%).

**Keywords:** AMC, Curve Number, HEC-HMS, NSE, R<sup>2</sup>.



Paper Id-144

## Application of ANNs to scour prediction around non-uniform piers

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### Abstract

The protected and economic bridge design requires the accurate estimation of the maximum scour depth at bridge piers. Existing research to estimate the scour depth focused mainly on uniform piers having constant cross-sectional dimensions over the full length. Practically the piers are non-uniform, rested over a foundation that includes large footing or caisson. The scour depth equations derived for uniform piers can't be applied for non-uniform piers due to variations in the scour mechanism. Very few researchers studied the effect of footing on local scour at non-uniform piers and established empirical equations from limited experimental outcomes. Also, the IRC method often overpredicts the design scour depth on Indian rivers. Hence, this study focused on finding an alternative approach such as Artificial Neural Networks (ANN) as a reliable scour model to predict the maximum scour depth at non-uniform piers using experimental data from the literature under clear-water conditions. The ANN model with Feed Forward Back Propagation (FFBP) algorithm has been presented. The optimum network with the number of datasets, network architecture, and sensitivity analysis are assessed. The *RMSE* values are 0.3333 and 0.6254 during calibration and validation, respectively, and the corresponding *R* values are 0.9863 and 0.9471. About 90% of the datasets are confined within the margin of  $\pm 25\%$  error. It is found that the developed ANN model is performing well in predicting the maximum scour depth. This may be due to their predictive capability to deal with non-linearity in the scour process. Thus, the proposed ANN model has proven to predict the maximum scour depth around non-uniform piers with high accuracy.

**Keywords:** Local scour; pier scour modeling; non-uniform piers; Artificial Neural Networks

Paper Id-211

## River Basin Scale Assessment of Impact of Land Use and Land Cover on Streamflow

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### Abstract

This study presents the impacts of LULC change on streamflow of Muvattupuzha river basin in Kerala, one of the worst hit regions during 2018 and 2019 Kerala flood, using Soil and Water Assessment Tool (SWAT). Analyses were carried out using LULC maps of six different time periods in which historical maps (1988, 1997, 2008 and 2018) were prepared from Landsat images employing maximum likelihood supervised classification and future projected land covers (2030 and 2050) were prepared using Land Change Modeler (LCM). SWAT model simulations using LULC change scenarios were carried out considering 30 years (1986-2015) simulation period with constant climate and changing LULCs. Calibration and validation of SWAT model for streamflow were carried out for two river gauge stations (Ramamangalam and Kaliyar) located inside the basin, which showed model performance is reasonably good in simulating the observed streamflow. Analysis from the LULC maps revealed that forest, plantations and built-up areas were the most affected land covers of which plantations



and built-up area showed an increasing trend at the expense of forest cover from 1988 to 2050. Streamflow showed increasing trend from 1988 (baseline) to 2050 for all the sub basins and downstream area of the basin is largely affected due to rapid urbanization in these regions. Annual average streamflow will increase up to 9.68% by the mid of 21<sup>st</sup> century from the baseline period. The proposed methodology can be used for other river basins to analyse the impact of LULC change, for water management practices.

**Keywords:** Land use; SWAT; land change modeler, runoff, hydrological modelling

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Paper Id-347

## SALINITY INGRESS STUDIES IN COASTAL STRETCH OF BHAVNAGAR TO UNA, GUJARAT, INDIA

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### Abstract

Management of ground water resources in coastal aquifers requires special attention to minimize the impact of sea water intrusion. Salinity studies in the coastal villages of Bhavnagar district and Una taluka need to be carried out to understand the dynamics of rainfall, variation of groundwater levels and the quality parameters for pre-monsoon and post monsoon periods. In this paper annual rainfall data trends are studied for the period between 2001 to 2019 for seven meteorological stations namely Bhavnagar, Ghogha, Talaja, Mahuva, Rajula, Jafrabad and Una. Furthermore, analysis of pre-monsoon and post monsoon static water levels, pH, Electrical conductivity, TDS, bicarbonates and chlorides is also carried out for some villages in Bhavnagar district and Una taluka. The average rainfall in study area is about 750 mm. The ratio of  $Cl / (CO_3 + HCO_3)$  and the amount of TDS in groundwater of study area is beyond the permissible limits which indicates the impact of sea water intrusion. Mahuva, Rajula and Una taluka consists patches of alluvial deposits, where the sea water intrusion effect is prominent. Groundwater use for drinking and irrigation requires proper assessment of salinity ingress in coastal areas so as to frame long term sustainable water management strategies.

**Keywords:** Salinity, Coastal aquifer, Ground water, Sea Water Intrusion.

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## Comparison of Estimators of Weibull Distribution for Low-flow Frequency Analysis

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### Abstract

Estimation of low-flow for a desired duration ('d' in day) and return period ('T' in year) is utmost importance for the assessment of water resources for many direct and indirect uses viz., municipal, irrigation, hydropower, public water supply, etc. This can be achieved through Low-flow Frequency Analysis (LFA) involving fitting probability distribution to the Annual Minimum d-day Average Flow (AMdAF) series derived from the daily stream flow data. This paper presents a study on LFA for river Godavari at Polavaram gauging site by adopting 2-parameter Weibull (WB2) distribution. Parameters of the WB2 are determined by five different methods such as method of moments, maximum likelihood method, L-Moments (LMO), Probability Weighted Moments (PWM) and principle of maximum entropy; and also used for estimation of low-flow for different return periods. The adequacy of fitting WB2 is evaluated by quantitative assessment using non-parametric Goodness-of-Fit (viz., Chi-Square and Kolmogorov-Smirnov) and diagnostic (i.e., correlation coefficient and root mean squared error) tests; and qualitative assessment using the fitted curves of the estimated low-flow. Based on qualitative and quantitative assessments, the study indicates the LMO (or PWM) is better suited for determination of parameters of WB2 distribution for estimation of low-flow for river Godavari at Polavaram.

**Keywords:** *Chi-square; Correlation coefficient; Kolmogorov-smirnov; L-moments; Low-flow, Mean squared error; Probability weighted moments; Weibull*

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**NIT ROURKELA**

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National Institute of Technology (NIT), Rourkela was founded as Regional Engineering College, Rourkela in 1961. It is a prestigious Institute with a reputation for excellence at both undergraduate and postgraduate levels, fostering the spirit of national integration among the students, close interaction with industry, and a strong emphasis on research, both basic and applied. It has been consistently ranked within TOP 20 engineering institutes for 5 consecutive years as per MHRD's NIRF, Govt. of India and has retained a good world ranking among its peer institutes. The city of Rourkela is a bustling industrial town, cosmopolitan by nature, and is well connected to all parts of the country by road and rail. It is en-route Howrah-Mumbai main line of South-Eastern Railway. Nesting amidst greenery on all sides, the NIT campus is approximately 7km from Rourkela railway station. The nearest airports are Jharsuguda, Ranchi, Kolkata, and Bhubaneswar.

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Civil Engineering is concerned with the improvement in the quality of basic needs of human civilization and taking care of the natural and humanly built environments with their planning, designing, construction, operation, and maintenance. The Civil Engineering Department at NIT Rourkela is earnestly working to develop solutions to major sustainability challenges of the country and committed to producing leaders impacting the society at large.

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The Indian Society for hydraulics (ISH) has established in the year 1992 as a technical, educational, and non-profit voluntary National organization to encourage and foster understanding amongst engineers, scientists, and other technical personnel engaged in various activities related to Hydraulics and Resources Engineering. Its main objectives include:

- To disseminate information through the conduct of Seminars/Conferences/workshops & Symposia.
- To encourage its member to update their knowledge, skills in and outside the country.
- To publish a paper to research/review/design and investigation in the Journal of Hydraulic Engineering for a wider audience.
- To accord recognition to the outstanding Researchers/Engineers who are striving hard in Hydraulics and Water Resources Engineering field.