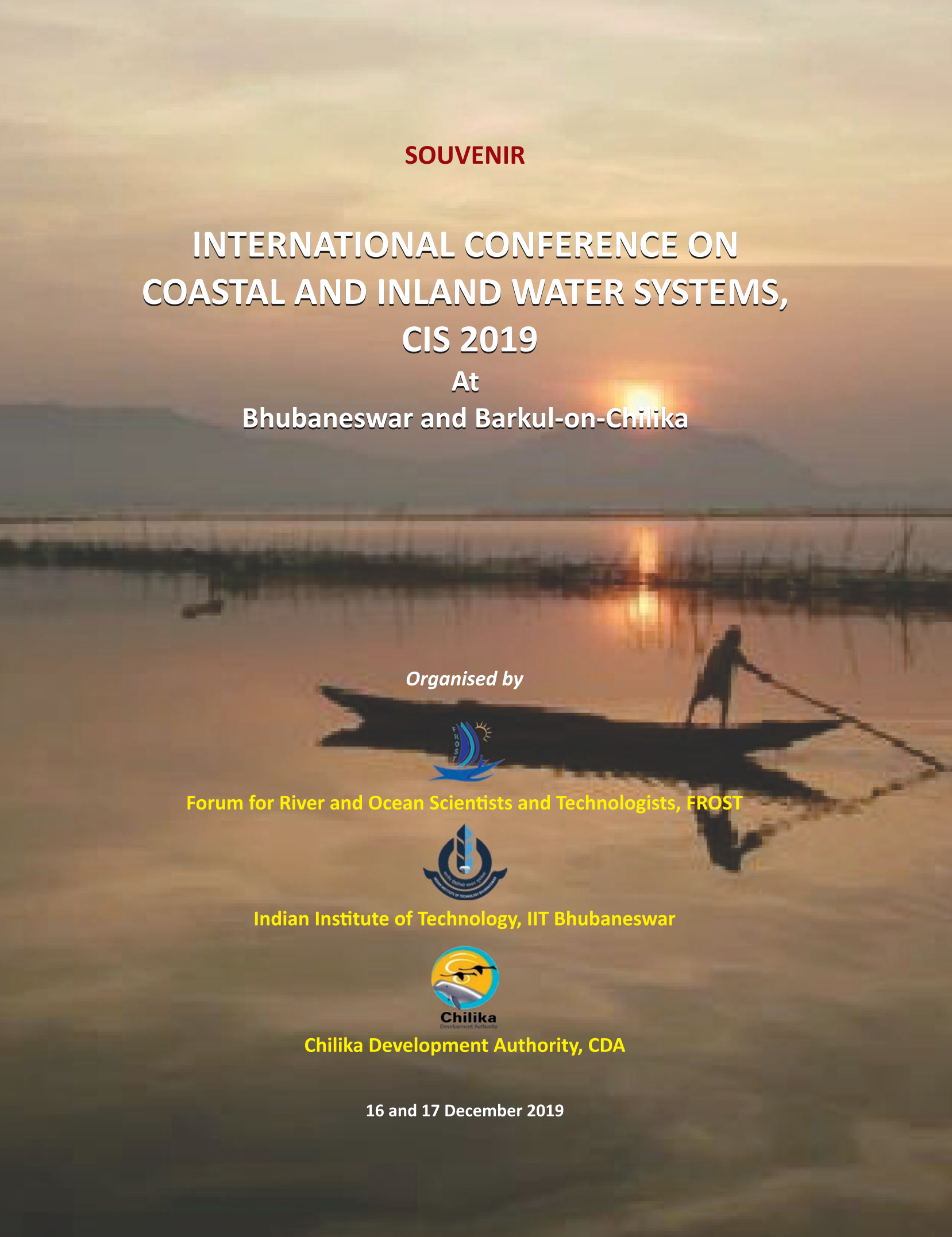

SOUVENIR

INTERNATIONAL CONFERENCE ON COASTAL AND INLAND WATER SYSTEMS, CIS 2019

At

Bhubaneswar and Barkul-on-Chilika

Organised by

Forum for River and Ocean Scientists and Technologists, FROST

Indian Institute of Technology, IIT Bhubaneswar

Chilika Development Authority, CDA

16 and 17 December 2019

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Indian Institute of Technology, IIT Bhubaneswar

Chilika Development Authority, CDA

16 and 17 December 2019

C O N T E N T

Prof. Ganeshi Lai
Governor, Odisha

ପ୍ରଫେସର ଗଣେଶୀ ଲାଲ
ରାଜ୍ୟପାଳ, ଓଡ଼ିଶା

सत्यमेव जयते

RAJ BHAVAN
BHUBANESWAR - 751 008

ରାଜଭବନ
ଭୁବନେଶ୍ୱର-୭୫୧୦୦୮

November 19, 2019

MESSAGE

I am glad to know that Forum for River and Ocean Scientists and Technologists (FROST) and NT Bhubaneswar in collaboration with Chilika Development Authority (CDA) is organising an International Conference on Coastal and Inland Water Systems (CIS 2019) at Bhubaneswar and Barkul on Chilika on December 16-17, 2019. A souvenir is also being brought out to mark the occasion.

The conference is viewed with great optimism to serve the urgent need of addressing contemporary water issues of concern like supply, storage, pollution and utility. Odisha has a long coastline and also navigable rivers, lakes, lagoons and canal water systems offering great potential and prospect of inland water transportation which is the most economical, energy efficient and environment- friendly. Therefore, it is pertinent to determine the extent of optimal development of our waterways in the interest of our overall economic development. The conference that brings together stakeholders in river & coastal water sector to integrate with mainstream development would be deliberating on enhancing awareness with regard to societal development, legislative means and executive or administrative action and also on mitigating the devastating effects of natural disasters. The endeavour of the organisers deserves commendation. I hope the conference with participation of professionals and experts would be highly productive.

I wish CIS 2019 and publication all success.

Ganeshi Lai

(Ganeshi Lai)

Tel. : 91-674-2536111/2536222, Fax : 91-674-2536582, E-mail : govodisha@nic.in, Website : www.rajbhavanodisha.gov.in

Asit Tripathy, IAS
Chief Secretary, Odisha

Phone(+91 674) 536700/4300
Fax: (+91 674) 2536660
e-mail- csori@nic.in
Bhubaneswar, 2019

MESSAGE

I am glad to know that a two day long International Conference on Coastal and Inland Water Systems (CIS)-2019 is being organized at Bhubaneswar and Barkul under the joint auspices of River and Ocean Scientists and Technologists (FROST), IIT Bhubaneswar and Chilika Development Authority on 16th and 17th December, 2019; and, a souvenir is being brought out to document the event for future reference.

Water is the *sine-qua-non* not only for all life forms on this Earth but also for industrial growth and agricultural prosperity. While preserving and promoting eco-systems, the water courses also provide for energy efficient transportation and communication. In recent decades, there has been a rising concern for conservation and quality improvement of both the surface and underground water aquifers. In several parts of Marathawada & Rajasthan, there have been reports of scuffles and community fights for access to safe drinking water. Even for a maritime State like Odisha, providing safe drinking water to all section of the population is a huge challenge considering fluoride, lead and iron contamination of ground water reserves. I hope, the conference will churn out workable solutions in these areas for future course of action.

I compliment the endeavors of the organizers for hosting this international conference in Odisha and wish that its outcomes will help wake up every stakeholder regarding the urgent need to conserve this natural resource.

(Asit Tripathy)

डॉ जी. सतीश रेड्डी
Dr. G. Satheesh Reddy

सत्यमेव जयते
भारत सरकार
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

सचिव, रक्षा अनुसंधान तथा विकास विभाग
एवं
अध्यक्ष, डीआरडीओ
Secretary, Department of Defence R&D
&
Chaiman, DRDO

MESSAGE

It gives me great pleasure to learn that Forum for River and Ocean Scientists and Technologists (FROST), IIX Bhubaneswar and Chilika Development Authority Bhubaneswar have come together to have a conference entirely on water based science and technology in rivers, lakes & lagoons and coastal seas.

With over 7500km of coastline, water based science and technology in rivers, lakes & lagoons and coastal areas has direct impact on the defence of our county.

I am sanguine that the coastal surveillance issues discussed in the conference will have a major significance for naval application and system design. I wish the conference a great success and hope that all participants would benefit immensely form the event.

Jai Hind

रक्षा मंत्रालय, रक्षा अनुसंधान तथा विकास विभाग, डीआरडीओ भवन, राजाजी मार्ग, नई दिल्ली-110011
Ministry of Defence, Department of Defence R&D, DRDO Bhawan, Rajali Marg, New Delhi-110011
दूरभाष/Phone : 011-23011519, 23014350, फैक्स/Fax : 011-23018216, ई-मेल / Email : secydrdo@hqr.drdo.in

डॉ समिर वी कामत
विशिष्ट वैज्ञानिक एवं
महानिदेशक (एनएस एवं एम)

Dr Samir V Kamat
Distiguished Scientist &
Director General (NS & M)

सत्यमेव जयते
भारत सरकार
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

रक्षा मंत्रालय
MINISTRY OF DEFENCE
रक्षा अनुसंधान तथा विकास संगठन
DEFENCE RESEARCH &
DEVELOPMENT ORGANISATION

MESSAGE

A large amount of research and development activity of defence areas is related to coastal waters, lakes and lagoons connected to the sea and rivers The conference on coastal and inland water systems is very timely to discuss various water based research and development It is also heartening to note that this conference will be held at two places, at Bhubaneswar and at Barkul on Chilika

I am sure the deliberations during the technical sessions will generate large amount of interest amongst researchers and students Apart from knowledge dissemination between the participants such conferences also generate interest in R&D related to various water issues.

I wish the conference all the success.

New Delhi
27th November, 2019

(Dr. Samir V Kamat)

Main Office : NSTL Campus, Vigyan Nagar, Visakhapatnam-530027, Tel : (O) 0891-2586550, 2558961, Fax : 0891-2558258
Delhi Office : 29, DRDO Bhawan, Rajali Marg, New Delhi-110011, Tel : (O) 23016706, 23016640, Fax : 011-23016706, Email : dgnsm@hqr.drdo.in

सुधीर गुप्ता
उत्कृष्ट वैज्ञानिक एवं
महानिदेशक (प्रौद्योगिकी प्रबंध)

SUDHIR GUPTA
Outstanding Scientist &
Director General (TM)

सत्यमेव जयते
भारत सरकार
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

रक्षा मंत्रालय
MINISTRY OF DEFENCE
रक्षा अनुसंधान तथा विकास संगठन
DEFENCE RESEARCH &
DEVELOPMENT ORGANISATION

MESSAGE

The conference on coastal and inland water systems being organised by three institutions of repute, the Forum for river and ocean scientists and technologists (FROST), IIT Bhubaneswar and Chilika Development Authority (CDA), is sure to generate large interest in the relevant areas amongst participating scientists. I also think the conference will discuss many new and innovative ideas to cater to the needs of the society with regard to water based developments. In modern times technology development is a multi skill, multi disciplinary activity and I am sure the conference will try to bring scientists of different disciplines together for overall water based technology development. I wish the conference all success.

Place : New Delh

Date : 29 November 2019

(Sudhir Gupta)

301, डीआरडीओ भवन, राजाजी मार्ग, नई दिल्ली-110011, दूरभाष : 91-11-23013476, फैक्स : 91-11-23013472
301, DRDO Bhawan, Rajali Marg, New Delhi-110011, Phone : (O) 91-11-23013476, Fax : 91-11-23013472
ई-मेल / Email : dgtm@hqr.drdo.in

Professor S. C. Misra
President, FROST

MESSAGE

At the regular meetings of FROST we have discussed the lack of awareness of various stake holders on water based activities in the state of Odisha which include the pathetic condition of Gangua river here in Bhubaneswar, coastal erosion, silting of lakes and lagoons, lack of drinking water, pollution of our water bodies, effect of natural disasters and global warming, lack of ship and boat building and repair industry etc. We took an audacious decision to hold a conference on coastal and inland water systems to generate awareness at a multi-dimensional level.

We approached Director IIT Bhubaneswar to join us in this endeavour who promptly agreed and suggested that this should be an international conference to bring in knowledge available in this area across the world. It was with great apprehension that we agreed to do so with virtually no financial support at that point of time. We approached Chilika Development Authority to collaborate with us and they promptly agreed to join us providing the entire Wetland Research Facility at Barkul for the conference. After this support, the conference was on strong footing.

The Naval research Board came forward to support us. Later, Inland Water Authority of India also came forward to support us in a limited manner.

This conference has been structured by inviting five eminent persons as speakers and inviting other authors in various areas of water body development. I am very happy to note that a number of eminent scientists and technologists from reputed institutions like IITs, universities and research and development institutions have contributed papers in the conference. More specifically, there have been a number of student authors and the conference has encouraged students to participa

Like any other conference this one will bring forward research and development activities in the water sector. Hopefully the message brought out in the deliberations will percolate down to stake holders in this area through interaction with delegates present and lead to activities for mitigation of water stress in future. I sincerely hope that the conference will satisfy its objectives well and I wish the conference all success.

International Conference on Coastal and Inland water Systems (CIS 2019)

(16th & 17th December, 2019)

Programme Schedule

16.12.2019	**Hotel Sandy's Tower, Bhubaneswar**	
08:30 to 09:30	Registration and Tea/Coffee	
09:30 to 11:00	**Inauguration**	
11:00 to 11:30	High Tea	
11:30 to 13:00	**Technical Session:Climate Issues**	
	Invited Lecture - Climate Change: Impacts, mitigation and Adaptation *Dr. Rao Y. Surampalli, Dr. Tian C. Zhang and Dr. Puspendu Bhunia*	30 min
	Coastal Hazards associated with Tropical Cyclones in a changing Climate over the North Indian Ocean Basin *Prof. Prasad K Bhaskaran*	30 min
	Assessment of Impact of Climate change on Streamflow using HEC-HMS case studyof Kesinga *Srinivasan D, Altafuddin Md., Ramdas M. and Panda R.K.*	30 min
13:00 to 14:00	Lunch	
14:00 to 15.45	**Techcal Session: Coastal Shipping**	
	Invited Lecture - ECO-Ships and System: Future of Shipping *Bodh Nath Prasad*	30 min
	Hydrodynamic Tests, Analysis and Simulations towards efficient Ship Design *Prof V A Subramanian*	30 min
	Kochi Water Metro – A Paradigm of inter-modal connectivity *Shaji Janardhanan*	30 min
	Study of Efficiency, Performance and Reliability of ORV Sagar Nidhi using Genetic Algorithm *D Rajasekhar, Anantha Krishnarao, D Narendrakumar & P S Deepaksankar*	15 min
15:45 to 16:00	Tea Break	
16:00 to 18.00	**Technical Session: Coastal Processes**	
	Invited Lecture - Water Stress – Can Oceans provide a Solution? *Purnima Jalihal*	30 min
	Biomimetic Propulsion Systems and their application to marine vehicles *Prof P Krishnankutty*	30 min
	3-D Marine Weather Foracast Dissemination System – PANORAMA *Commodore Manoj Kumar Singh*	30 min
	Characteristics and Variability of Sea state in Gulf of Mannar –An Analysis using Moored Buoy Observations and model results *K N Navneeth, K Jossia Joseph, Reddy Jankiramand R Venkatesan*	-
	Application of Artificial Neural Network in Siltation Studies *Dhanya S and H V Warrior*	15 min
	Projection of Wave Climate into the future due to Climate change *R Bhavithra and S A Sannasiraj*	15 min

18.00 to 19:00 Break

19:30 to 20:30 Cultural Programme

20:30 to 22:00 Conference Dinner

17.12.2019 **Wetland Research Centre, CDA, Barkul**

07:00 Bus starts from Hotel Sandy's Towers, Bhubaneswar to Barkul

09:30 to 11:15 **Technical sessions – Inland Water Transport**

Invited Lecture - Inland vessel design for Hydrodynamic Efficiency
D S Praveen, Mohammed Ashiqu, O P Sha, Bijit Sarkar 30 min

Battery powered FRP Hull 60 PAX Electric Vehicle for riverine transportation
N R Mandal 30 min

Inland waterway Transport development in Assam – Long term Strategy
R M Das (presented by Capt. Indervir Solanki) 15 min

Novel Anti-fouling paints and paint schemes for Coastal Vessels
M Joshi, A Mukherjee, S C Misra, U S Ramesh and T P Bhamra 15 min

Smart Jetty
Prayag Raviprakash, Syam Sreedharan K N and K Sivaprasad 15 min

11:15 to 11:45 Tea Break

11:45 to 13.45 **Technical Session: Operation of Inland and Coastal Vessels**

Invited Lecture - Exciting options for Ships for Operation in Indian Coast and Rivers
Dilip Sarangdhar and KandhaMantry 30 min

Manoeuvring of Inland Vessels in Riverine Waterways
Capt. Indervir Solanki 30 min

Nano fuel additives: An Innovative technology for Ship Emission Reduction
D Rajasekhar, AnanthaKrishnarao, D Narendrakumar and P S Deepsankar 30 min

Reduction of carbon footprint and operating costs of vessels operating in inland waterways by reducing frictional resistance
Lt.Cdr. Paul S Moses 15 min

Contemporary Issues and problems for the regulation, development and management of the inland waterways for navigation and promotion of IWT in India
S Dandapat 15 min

13:45 to 14:30 Lunch

14:30 to 16.00 **Technical Session: River and Lagoon Systems**

Resurrection of the Geo-chemical Morphology of River Gangua towards its restoration as a river for Tourism and Flood Control
Purnendu Misra and J K Rath 30 min

A Geo-statistical approach for contour mapping and spatial variability of ground water in and around Rourkela, Odisha, India
Rabindranath Barik and Sanjay Kumar Pattanaik 30 min

A Study of vulnerability of Indian water resources from the aspect of Climate Uncertainty
Sneha P S, Chipy Lucy, Ashlin Joy and Amaljit Sivan -

	Benthic fauna response to seasonal and spatial changes in the Lagoonal water characteristics *Sushree Sova Barik and Raj K Singh*	15 min
	Assessment of environmental Flow in humid tropical basin using Hydrologicaal methods *Alka Abraham and Subrahmanya Kundapure*	15min
16.00 to 16.30	Tea Break	
16:30 to 18.15	**Technical sessions : Coastal Surveillance**	
	Review of Coastal Surveillance requirements and possible solutions from Security prospective *Jojish Joseph and Ajit Kumar K (*to be presented by *Praveen Kumar N.)*	30 min
	Battering the Battered Indian water Health: from daydreaming to Pragmatic Proactivity *Nagappa Ramaiah (*to be presented by *Purnendu Misra)*	30 min
	Effect of non-sinusoidal pitching profile on Propulsive performance of an Oscillating Foil *Ashok B and Govardhan R N*	15 min
	High Speed Coastal Patrol Vessel cum Emergency Flood Rescue Vehicle *Bharath Murali, Adithyan A K and Rishikesh U*	15 min
	Advanced Radars and 5G Technology in Maritime Surveillance *Nishant Gurjar*	15 min
18:15 to 18.45	Valedictory Function	
18:45 to 19:30	Break	
19:30 to 20:30	Cultural Entertainment program	
20:30 to 22:00	Dinner	
18.12.2019	Wetland Research Centre, CDA, Barkul	
05:30 to 09:00	Boat ride to Nalabana for witnessing migratory birds	
09:00 to 10:00	Breakfast	
10:00	Departure to Bhubaneswar by bus	

END OF CONFERENCE

CHILIKA DEVELOPMENT AUTHORITY (CDA)

Chilika Development Authority (CDA) was created vide Resolution no.20369/F&E dated Bhubaneswar the 20/11/1991 F&E Department, Govt. of Orissa. CDA is the key institution mandated by State Government to undertake conservation and management of Lake Chilika. The authority is chaired by the Chief Minister, which signifies the high priority accorded by the government to wetland conservation. Secretaries to the state government departments of forests and environment, fisheries and rural husbandry, tourism, revenue and finance; members of legislative assemblies of Bramhagiri and Chilika; collectors of Puri, Khurda and Ganjam; Agriculture Production Commissioner and Director, WISA are the current members of the Governing Body. The Executive Committee chaired by the Principal Secretary (Forest and Environment) is responsible for taking executive decisions pertaining to CDA. The Chief Executive of the CDA is entrusted with implementation of various programmes and work plans, and management of the CDA.

Objectives of Chilika Development Authority:

a) To protect the lake ecosystem with all its genetic diversity.

b) To survey, plan and prepare the project proposal for integrated resource management for all round development in and around the lake.

c) To execute various multidimensional and multidisciplinary developmental activities either itself or through some agency.

d) To cooperate and collaborate with other institutions of the state, national or international institutions for all round development of the lake.

e) To establishment management information system for the lake.

f) To promote long term multidisciplinary research, prepare environment status report and establish education centre for the lake.

g) To facilitate: 1. Control of silt load of streams and rivers and desiltation. 2. Watershed management, opening of mouth area and maintenance of salinity gradient. 3. Scientific management of weeds. 4. Sustainable development of fisheries and aquacultures. 5. Conservation of wild life. 6. Eco-restoration of islands including habitat improvement of birds 7. Capture and culture fisheries in Chilika Lake and on land around it. 8. Construction of roads. 9. Opening of mouth of the lake or opening of new mouth. 10. Moderation of lake level within the safe limits. 11. Promotion of ecologically compatible domestic and international tourism. 12. Socio economic development of the area.

h) To conduct environmental impact assessment studies from time to time. i) To upgrade the management and professional skills of the members associated with conservation and development of the lake.

CDA has also established a visitor information and interpretation centre at Satpada, Puri. Wetland Research and Training Centre (WRTC) which is the nodal laboratory of CDA is located at Balugaon about 100 km from Bhubaneswar. WRTC conducts monitoring and research in the field of limnology, marine biology, hydrology, coastal influence on the Lake, flora and fauna, advanced oceanographic and hydrological studies like sediment transport, wave climate, tidal influence, Lake bathymetry.

Renovation and up gradation of WRTC had been completed through the support received from the World Bank under the ICZMP Odisha component. State-of-the art facilities for research in data modeling, biogeochemistry, molecular biology, and biotechnology have been established at WRTC. Monthly monitoring of more than 30 physical and biological parameters is conducted from 33 GPS fixed stations of Chilika Lake. The research studies have resulted for the first time a comprehensive understanding of Lake Biodiversity including knowledge on microbial communities, water quality, impact of cyclone, fisheries, phytoplankton, benthic communities, and seagrasses. The output from the studies is incorporated in to the ecological and mathematical modeling with a decision support system for the lake.

IIT BHUBANESWAR

The **Indian Institute of Technology Bhubaneswar** was established by the Government of India in 2008 under The Institutes of Technology Act 1961 with Amendments upto 2012 and was declared an Institute of National Importance on 29thJune 2012. The Institute which had its humble functioning from the campus of IIT Kharagpur initially shifted its operation to the city of Bhubaneswar on 22nd July 2009 and then its permanent campus at Argul, Khorda since 14th July 2018. The Institute runs 7 schools offering academic programmes in B. Tech., M.Sc, M.Tech. and Ph.D. degrees in diverse disciplines like Computer Science, Civil, Electrical, Electrical & Communication Engineering, Mechanical Engineering, Metallurgical and Materials Engineering, Basics Sciences, Geology, Atmospheric & Ocean Sciences and Climate Science & Technology to name a few.

The institute is committed to provide holistic education aimed at producing tomorrow's leaders, nurturing personality, creativity, innovative mind-set and capability be it in Science or Technology or Management or in other domains of human excellence. The Institute provides well qualified faculty, state-of-the art infrastructure facilities creating a conducive environment for rapid growth of the students' skill sets in all aspects of the personality – academic, research, cultural, sports, ethical and social responsibility. Numerous collaborations with foreign universities, industries and institutions across the world provides a scope to the students to be exposed to the global trends in education, research and industry. Ample opportunities in both national and international stints for internships, research projects and exchange programs has been a prominent trend among our students.

During last 10 years the Institute's faculty members and students have contributed to creating knowledge by publishing more than 1850 original research papers in reputed national and international Journals and Conferences and winning several awards in conferences and competitions.

IIT Bhubaneswar was ranked 18th in engineering category by the National Institutional Ranking Framework in 2018, 10thin India by India Today in 2018, 20thwithin India by i3RC Times Engineering Institute Rankings 2018 (among 150 Engg. Colleges),10thin India by Times Higher Education, 601-800 rank across the world (among 1258 Institutes), 21st rank within India,107th rank within BRICS countries, 20th within India & 153rdwithin emerging countries by Times Higher Education Emerging Economies University Rankings 2019, 10th in India best public Engineering Institutes & overall 22nd rank among public Institutes in India as per Careers360 Magazine Ranking of India's Best Universities-2019, and 9th best Engineering College in Government Category in India by India Today MDRA survey.

The **Vision**of the institute is to be **a highly respected Institute in the world for its distinctive knowledge**.

The defined **Mission** of IIT Bhubaneswar is to shape itself into a learning community with cooperation and respect between each other while encouraging and facilitating the faculty, researchers and students to work synergistically across discipline boundaries. The Institute further aims to infuse a sense of excitement in students in innovation & invention, design & creation and entrepreneurship through development and perusal of dynamic, flexible and holistically designed curriculato facilitate creativity and cognitive thinking and strive for productive partnership between the industry and the Institute.

Over its decade of existence, the Institute has embarked upon active research, skill development and societal outreach in some of the niche areas of relevance to this this region of the world. The Institute has been vigorously pursuing research in the areas of climate change, extreme weather events, coastal pollution & erosion, and similar such areas of direct relevance to the society. Over the years, the Institute has become home to many Centres of Excellences in fundamental and interdisciplinary research, start-up centres and an incubation hub independently as well as in collaboration with several industries, organisations and academia of national and international repute and is marching towards fulfilling its mission at a steady and sustained pace.

NAVAL RESEARCH BOARD

Vision: Make India prosperous by establishing world class academic research base in the frontiers of science and technology to support the present and future needs of defense and security of the nation.

Mission: To encourage and fund basic and applied research in pertinent scientific disciplines relevant to DRDO by enabling and supporting emerging talent in academic institutions & to create and evolve a knowledge-base.

NRB Function:

- Supports basic & directed research to generate new knowledge potentially useful to the Navy and to train young minds to apply that knowledge for naval purposes.
- Sets down the principles and practices governing the relationship of DRDO with academic "think tanks" and other R&D agencies.
- Approves research programs for funding based on evaluation and recommendations of specialist-panels.

Approach

- Interaction with academia
- Involvement of renowned experts in project evaluation, monitoring & review
- Participation of user labs & Indian Navy
- Sponsoring Seminar/ Conference/ Workshop etc

NRB Panels: Scheme is coordinated through 7 Specialist Pales:

1. Sonar and Signal Behaviour (SSB)
2. Hydrodynamics Panel (HYDRO)
3. Marine Systems Panel (MAR)
4. Ocean Environment Panel (OEP)
5. Scientific Computing Panel (SC)
6. Materials Panel (MAT)
7. Hydro-Vibro-Acoustic Panel (HVA)

Thrust Areas of Research are available on DRDO website/NRB

Contact: Member Secretary, Naval Research Board, Room No 322, DRDO Bhawan, Rajaji Marg, New Delhi-11
Tel (O) 011-23007808, 23007333, 23007322, e-mail: dnrdoff@hqr.drdo.in, Website: www.nrbdrdo.res.in

Prof. SC Misra, NRB Chairman

NRB PANELS CHAIRMEN

Materials Panel (MAT)

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E-mail : drcvk1953@gmail.com

Sonar Signal Behaviour Panel (SSB)

Dr. PS Ramaiah, Andhra University
E-mail : psrama@gmail.com

FORUM FOR RIVER AND OCEAN SCIENTISTS AND TECHNOLOGISTS

Background

It is well known that water transportation is the cheapest mode of transportation compared to rail, road or air. It is also the safest mode and the least environmentally polluting mode of transportation, though it carries with it normal security risks. It also takes off load from road and rail. Inland, coastal and ocean waters can be used for tourism and harvesting of resources particularly fishing. This leads to large scale industrial growth particularly in small and medium sector leading to large employment generation.

Inland waterways and coastal waters are the least developed in India, particularly in the State of Odisha in spite of being a coastal state with around 480 km of coast line, which includes many rivers and the Chilika lagoon. Boats frequently capsize causing loss of life and boat. There is hardly any cargo movement, no water sports or tourism in spite of vast potential of eco-tourism and heritage tourism. Fishing activity is primitive and unsafe. The rivers and Chilika lagoon with its vast potential resources get silted, the beaches get frequently eroded leading to population migration along the coast. River waters are polluted and unsafe for human use. The administrative and regulatory mechanism in this sector is almost non-existent.

Objective

Though small in number, a group of specialists and experts have come together having expertise in the following areas:

- Oceanographic study areas – academic and research
- Technologies in the maritime sector
- Technologies in the shipbuilding and industrial sector
- Technologies and sciences in the riverine sector
- Sustainability areas in the water sector

FROST has been conceived as a conglomoration of this group of people who would provide a thought process (think tank) for growth in an independent manner based on collective knowledge and discussions. Apart from exchange of news and views related to development of entire river and waterfront ecology and infrastructure between members, the Forum is to generate awareness amongst administrators, beaurocrats and public in general in relevant areas, disseminate knowledge and skill to various stake holders and students, assist government and other stake holders in developing a road map for progress in this sector, policy generation for this purpose and highlight immediate issues of concern and growth as and when necessary. The group also evinces keen interest in maritime history and marine archaeology.

Activities undertaken

- Seminar on Safety of Boats, 18th January, 2017 at Bhubaneswar
- All India seminar on Inland and coastal Shipping, 18-19 November, 2017 at Bhubaneswar
- Stake holders' meet on Safety of wooden boats at CDA, Barkul on 31t march 2018
- Guidance and advice on Modification of wooden tourism boat of CDA in Chilika
- Meeting government officials, CDA officials and interested parties highlighting the need for water systems development
- Popular lectures at schools and colleges.
- Archeological studies on Water front
- Expletory studies on Odisha Maritime history, Ship building, Sea trade etc.

Membership

Membership is open to all professionals, administrative officials, students, retired senior citizens interested in the development of the water based sectors. All that is required is recommendations from two executive committee members.

Bodh Nath Prasad
Executive Director
IS Container Pte Ltd., Singapore

Topic

"ECO-Ships & System: Future of Shipping"

- New Eco-designs and electronically controlled Main Engine, etc. envisage more training. There has be more focus on engineering side, due to complexity of new processes, demands for efficiency and emissions reductions. The operational margins are narrow and precise than before.
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- Big Data and Performance management tasks mean augmented efficiency focus. With the advent of advanced sensors arrays and broadband connectivity, now it is possible to transmit all ship's operating data to shore. A shore based control centre can guide the vessels in operations of machinery, cargo care and navigation in bad weather as well approaches to harbour etc.
- Integration of intelligent Propulsion systems, Various Condition Based Monitoring (CBM) for machineries; vessel efficiency measures have resulted in great saving in fuel and maintenance costs.

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WEF Fellow, Hon. D.WRE, F.AAAS, Dist.M.ASCE

Prof. Rao Y. Surampalli is President and Chief Executive Officer of the Global Institute for Energy, Environment and Sustainability. He was with the U.S. Environmental Protection Agency (USEPA) for 29 years and retired as an Engineer Director. He received his M.S. and Ph.D. degrees in Environmental Engineering from Oklahoma State University and Iowa State University, respectively. He is a Registered Professional Engineer in the branches of Civil and Environmental Engineering, and also a Board Certified Environmental Engineer (BCEE) of the American Academy of Environmental Engineers (AAEE) and a Diplomate of the American Academy of Water Resources Engineers (DWRE). He is an Adjunct Professor in seven universities and Distinguished/Honorary Visiting Professor in seven universities. Currently, he serves, or has served on 73 national and international committees, review panels, or advisory boards including the ASCE National Committee on Energy, Environment and Water Policy. He also served as Governing Board Member of EWRI, Board of Director of AAWRE and CEC Inc., and President of ASCE Civil Engineering Certification (CEC Inc.),an entity of ASCE for Board Certification of various specialties within civil engineering. He has received over 30 national awards/honors from various professional organizations: including the NSPE 22nd National Engineer of the Year; ASCE Simon-Freese Prize, Hering Medal (thrice), Greely Medal, Horner Medal and the State of the-Art-of-Civil Engineering Award (thrice); WEF Philiph Morgan, Eddy and Emerson Medals; AAES Palladium Medal; AAEES Kappe Lecture and Gordon Maskew Fair Awards.He is a Distinguished Engineering Alumnus of both the Oklahoma State (OSU) and Iowa State Universities,and was also inducted into the OSU Engineering Hall of Fame in 2015.He is an elected Fellow of the American Association for the Advancement of Science, an elected Member of the European Academy of Sciences and Arts, an elected Member of the Russian Academy of Engineering, an elected Fellow of the Water Environment Federation and International Water Association, and a Distinguished Member of the American Society of Civil Engineers. He also is Editor-in-Chief of the ASCE Journal of Hazardous and Toxic Waste, and Nanotechnology for Environmental Engineering (a Springer Journal), past Vice-Chair of Editorial Board of Water Environment Research Journal, and serves on the editorial boards of 8 other refereed environmental journals. He has authored over 700 technical publications, including 22 patents, 24 books, 151 book chapters, 372 refereed journal papers, and 241 national and international conference presentations, and presented over 150 plenary/keynote or invited presentations worldwide.

Dr. O. P. Sha received his B.Tech. (Hons.) degree in Naval Architecture from the Indian Institute of Technology, Kharagpur in 1980; M.Sc. in Ship Production Technology from the University of Strathclyde, Scotland, United Kingdom, in 1982; and Ph.D. in Engineering from the Indian Institute of Technology, Kharagpur in 1996. Presently, he is a Professor in the Department of Ocean Engineering and Naval Architecture. He was the Head of the Department of Ocean Engineering and Naval Architecture from October 2010 to September 2013 and subsequently the Dean of Continuing Education from October 2013 to September 2016 at the Indian Institute of Technology, Kharagpur. He teaches a wide variety of subjects at the Institute and his main areas of interest include ship design and production, CAD/CAM and high performance vehicles. He is currently involved in a number of sponsored research and industrial consultancy projects with DRDO, Indian Navy, Ministry of Shipping, Garden Reach Shipbuilders and Engineers Limited, Cochin Shipyard Limited, L&T Shipbuilding, Kolkata Port Trust, IWAI, SHOFT Shipyard, etc. He is the Chairman, Hydrodynamics Panel of Naval Research Board, Govt. of India. Prof Sha was the Honorary Secretary (2008-2010) and Chairman (2016-2018) of the Institute of Engineers, Kharagpur Chapter. He has a number of publications in the area of Ship Design and Production and has guided a number of doctoral and postgraduate students. Currently he is associated with design of inland vessels on the river Ganges for the Govt. of India's *Jal Marg Vikas Project.* He has been entrusted by the Sagarmala Cell of Ministry of Shipping and IIT Kharagpur to head the Centre for Inland and Coastal Maritime Technology (CICMT) at IIT Kharagpur where the country's first shallow water seakeeping and manoeuvring basin for ship-model testing will be set up. This will provide impetus to research and development in the area of inland and coastal maritime technology.

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Dr Purnima Jalihal is a senior scientist who heads the Energy and Fresh Water group in the National Institute of Ocean Technology, India. She has coordinated many first – ever projects in ocean energy and desalination. She has a tremendous contribution in the setting up of the first ever ocean thermal gradient based desalination plant at Kavaratti island in the Lakshadweep group in the Arabian Sea which has helped transform the lives of the small islandcommunity which had a serious lack of drinking water. For this work she was awarded the Vishwakarma Medal in 2006 by the Indian National Science Academy. This success led to more plants in islands and also a demonstration offshore. She also has led device developments for harnessing ocean energy from waves, marine currents and ocean thermal gradient (OTEC). The technology for the wave energy powered navigational buoy for use in ports, has been demonstrated successfully and is now being transferred to industry. The marine hydrokinetic turbine was successfully demonstrated in Andaman and a design for an off-grid unit for an installed capacity of 5 kW is now ready. The first ever wave powered desalination system was also demonstrated at Vizhinjam, Kerala under her leadership. Dr Purnima is now attempting to scale up the technologies. Currently a large scale desalination plant at Tuticorin thermal power station using the condenser reject heat and an OTEC powered desalination plant in Lakshadweep are on the anvil. She has a PhD in Civil Engineering from Duke University, USA. She is on many committees of Indian Government organizations, related to water and renewable energy. She represents India in the international forum Ocean Energy Systems -Technology Collaboration Program (OES-TCP) of the International Energy Agency (IEA). She is also the Chairperson of the Indian Desalination Association – South Zone.

Mr. Dilip Sarangdhar is a Naval Architect by profession, he graduated from the Indian Institute of Technology, Kharagpur, in 1972 with First Class (Honours).

Mr. Dilip now has over 47 years of experience in the marine industry, most of it in Ship design and Ship classification field.

Mr. Dilip started his career in the Design department of Mazagon Dock Ltd, Mumbai and later in 1977moved to the Indian Register of Shipping.

In more than 3 decades with IRS, he held many responsibilities which included Head of Plan Approvals, Rule Development and Research. In the last position as Dy. Managing Director, Mr. Dilip had the overall responsibility for R&D, Software Development, Rule Development, Training, IT, Recruitment and Business Process Review functions. He was also a member of the international Rule making Groups - IACS Working Party on Strength of Ships and later the IACS Hull Panel for more than 15 years.

After retiring from IRS in 2008, Mr. Dilip joined SeaTech Solutions International (S) Singapore, one of the largest independent Ship Design and Marine Consultancy organizations in the ASEAN region. At SeaTech Mr. Dilip leads Innovation and Conceptual Designs for new special application projects. He oversees the technical aspect of projects, provides technical expertise and advice, designs and integrates systems of all equipment on board ships. Notably he was the Lead Naval Architect & Project Manager for SeaTech's prestigious ship design project of **World's First Deep Seabed Mining Vessel** right from the **Concept Design to Final Design**.

Mr. Dilip' s experience and expertise in many aspects such as Naval architecture, Structural Analysis, Hydrodynamics and Machinery systems and his familiarity with the Rules and their technical background certainly helps him in pursuing his passion for innovative Ship Design.

INLAND VESSEL DESIGN FOR HYDRODYNAMIC EFFICIENCY

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ABSTRACT

In a developing country like India, there is enormous potential for its inland waterways where most of the land masses are connected through inland waterways. As demand for transportation of cargoes through water is increasing, it becomes more important to estimate the power of the vessel and optimize the design so that the entire voyage becomes economically beneficial. Unlike conventional deep water cases, the flow characteristics around the hull in shallow water changes significantly. These changes result in an increase in resistance, and it is crucial to know the maximum speed which can be attained by minimum fuel consumption, and it varies depending on few parameters like depth of the channel, beam of the vessel, etc. Here, in this paper, we will discuss the estimation of resistance and powering of the vessel in shallow water by using established empirical methods and do a comparative study among different methods.

KOCHI WATER METRO – A PARADIGM IN INTER MODAL CONNECTIVITY

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ABSTRACT

Kochi, an Indian city located at the centre of a rapidly urbanizing coastal and estuarine region. In Kochi, a port city characterized by crisscrossing canals and rivers connected to a backwater system, waterways used to play a major role in the socio-economic and cultural development of the region. The Kochi Water Metro Project (KWMP) is a special innovative project whose 'dejure' owner is Government of Kerala, with an intent to improve urban water transport system in Kochi, connecting 10 islands around the Ernakulam mainland.The proposed waterways aim to integrate the system with the other modes of transport such as city buses, metro feeders, non-motorized transport etc. as well as the metro system over a period of time with an integrated fare and integrated timetable. The water metro project is envisaged as a game changer, to bring back water transport as one of the urban transport instruments, which are environmental friendly, safe and modern transport system.

ECO-SHIPS & SYSTEM: FUTURE OF SHIPPING

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ABSTRACT

- New Eco-designs and electronically controlled Main Engine, etc. envisage more training. There has to be more focus on engineering side, due to complexity of new processes, demands for efficiency and emissions reductions. The operational margins are narrow and more precise than before.
- ECDIS and Modular Bridge facilitate navigation but does not reduce constant attention required.There is considerable evidence that some crew are not sufficiently skilled and omits "Safe practices".For example, the major cause of total losses in shipping is 'vessels floundering' with 46 ships sinking in 2016.
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- Integration of intelligent Propulsion systems, Various Condition Based Monitoring (CBM) for machineries; vessel efficiency measures have resulted in great saving in fuel and maintenance costs.

EXCITING OPTIONS FOR SHIPS FOR OPERATION ON INDIAN COAST AND RIVERS

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ABSTRACT

India has an extensive network of inland waterways in the form of rivers, canals, backwaters and creeks. The advantages of transport by water over that by rail or road in terms of cost per tonne-mile of cargo and the green houses gases are very well known and there is a broad agreement our coastal shipping and inland waterways shipping must increase substantially from the current meagre share of 7% of the domestic cargo. Promotion of coastal and inland waterways shipping is therefore essential due to the potential economic and social benefits it could confer.

Sagarmala and Jal Marg Vikas Projects undertaken by the government are very encouraging and reflect the urgency and determination to change this picture and increase the share of domestic cargo movement on water. Construction of multi modal terminals, ports and jetties under these projects would encourage cargo movement from hinterlands as well as establishment of industrial and commercial centres around these facilities would increase the shipping demand and prospects further.

The paper discussesthe current status and opportunities for ships operations on Indian coast and rivers. The paper also discusses types of vessels, salient desired features, costs drivers, emission issues, and propulsion options etc that are relevant considerations for ship design.

CLIMATE CHANGE: IMPACTS, MITIGATION AND ADAPTATION

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ABSTRACT

There are well documented facts that greenhouse gas (GHG) emissions have significantly contributed to global climate change. Although there are several GHGs, carbon dioxide (CO_2) contributes the highest proportion of green house effect mainly because of its higher concentration in the atmosphere. The greenhouse effect of constantly rising emissions of GHGs is responsible for the global climate change, particularly in terms of overall global warming though the condition varies with the regions, as either cooling, or wetter weather can be experienced at various regions; while on average the temperature of the planet is rising. Global climate change is also being experienced in various other types of global and regional scale changes; for example, melting of the glaciers and ice caps, droughts, hurricanes, floods, forest fires, etc. that threaten fragile eco-systems and affect migration of species.It is utmost important to step forward to reduce GHGs, mitigate climate change and evolve adaptation strategies at the earliest so as to prevent negative impacts on human society andthe ecosystem. This presentation provides understanding and information about GHGs emissions, the current status and impacts of climate change, and the associated mitigation/ adaptation strategies.

The potential climate change impacts include global warming, changes in weather patterns/ precipitation, and sea level rise. Specifically, health impacts associated with climate change could be an increase in weather-related mortality, infectious diseases, and air quality-respiratory illnesses. Impacts on agriculture, forest and ecosystems include crop/forest health/yields/composition, shift in the ecological zones and geographic range of forests, and losses of habitat/species. Impacts on water resources may include change in water supply and quality, increased competition for water, more frequency of extreme weather, and shift of irrigation demands. The melting of glaciers, snow and ice causes sea level rise, which erodes the coastand damages many economic means of

NOVEL ANITIFOULING PAINTS AND PAINT SCHEMES FOR COASTAL VESSELS

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ABSTRACT

The major issues in coastal environments include eutrophication, habitat modification, hydrologic and hydrodynamic disruptions, and exploitation of resources, toxic effects and the introduction of non indigenous species. Shipping, both coastal and international are primarily responsible for the introduction of non-native species and partially responsible for toxic effects in coastal waters. Shipping is the primary vector for the introduction of non-indigenous or non-native species which is now a very serious environmental concern. The Ballast Water Management Convention, adopted by IMO in 2004, aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments. The BWM Convention entered into force on **8 September 2017**. It was previously thought that ballast water was mainly responsible for this effect; however recent studies have shown that hull fouling is a major factor. Virtually all vessels are coated with "self-polishing" anti-fouling paints to prevent fouling on ships hulls. These coatings not only introduce large quantities of biocides that are toxic to non-target organisms, but also that the antifouling painting schemes, currently in vogue, lead to premature depletion of anti-fouling film in certain niche areas. The breakdown of antifouling protection in these areas, leads to the attachment of various marine organisms and act as a vector for the transmigration of invasive species. The use of natural biocides such as Neem and Karanjin extracts have shown promising anti-fouling properties and due to their low persistence in the aquatic environment are less toxic to non-target marine organisms. Further, optimizing the antifouling painting schemes to prevent premature failure of antifouling protection could drastically reduce the propogule pressure for the transmigration of invasive species. A methodology has been developed by first conducting a CFD analysis of wall shear stresses on the vessels hull to identify areas of high risk of antifouling coating failure, followed by an experimental procedure using a "Drum-Test" apparatus has been developed to optimize antifouling painting schemes to reduce the risk of transmigration of Invasive species.

COASTAL HAZARDS ASSOCIATED WITH TROPICAL CYCLONES IN A CHANGING CLIMATE OVER THE NORTH INDIAN OCEAN REGION

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ABSTRACT

Tropical cyclones are one among the natural hazards that create havoc and loss of life and property during landfall in the North Indian Ocean region. Recent research shows clear evidence on increased intensity and size of tropical cyclones that forms over the North Indian Ocean basin that is linked with climate change. A detailed mapping on the tropical cyclone induced storm surge and associated inundation along the East coast of India is reported for two cyclone events viz; *Aila* and *Hudhud* events. The importance of a coupled wave-hydrodynamic model that improves coastal and nearshore extreme water levels during very severe cyclone cases is also discussed. The study also presents a detailed validation of various parameters such as significant wave height, storm tide, and flooding scenarios associated with the extreme event against the field measured data.Finally, the key challenges, priority areas and knowledge gaps identified for a detailed research on tropical cyclones will be highlighted.

WATER STRESS – CAN OCEANS PROVIDE A SOLUTION?

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ABSTRACT

Increasing population, high rate of industrial growth and climate change together have led to the severe water stress today. It has become imperative to find means to augment water. Seawater desalination is being seen as a viable option especially since India has a long coastline. Various methods of desalination are discussed along with the impacts on climate change. The National Institute of Ocean Technology (NIOT) has pioneered an ecologically safe thermal desalination method suitable for implementation in islands, offshore and in power plants near the coast called Low Temperature Thermal Desalination (LTTD) and the paper showcases the achievements. The environmental as well as ecological cost has to be considered for a meaningful comparison of desalination technologies and this is also presented. The way forward may be to power desalination systems using renewable energy sources.

BATTERY POWERED FRP HULL 60 PAXELECTRIC VEHICLE FOR RIVERINE TRANSPORTATION

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ABSTRACT

Serious concern for environmental protection by reducing carbon foot print has led to the development ofelectric vehicles for various modes of transportation and naturally river transportation is also no exception.The propulsion engine being electric motor, power is drawn from a rechargeable battery bank of adequate capacity for the required endurance. The power for charging of the battery bank will be drawn from a solar powered pumped storage facility on shore. For the cloudy days, a grid based shore connection will also be kept.Two numbers brushless DC (BLDC) motors each of about 7.5 kW power will be used to propel the vessel at a minimum 8 knots cruising speed in calm water. The motors will be operated remotely from the wheel house.

It is designed to carry 60 passengers along with their personal effects of reasonable amount in the sheltered waters of river Ganga. The vessel is meant for ferrying people across the river at different locations from Malda to Diamond Hourbour.Integrated FRP seats will be provided on the main deck. Access to the seating area is provided through four entry/exit points, two each on port and starboard sides. These entry/exit points will be provided with suitable sliding opening and closing gates.

This proposed propulsion system not only eliminates the polluting emission of conventional hydrocarbon based propulsion engines but also results in various additional benefits, such as Least noise pollution, zero air pollution during its operation, electric motor will lead to substantial energy savings, power consumption cost of a battery powered vessel is about 1/3rd that of a conventional diesel powered vessel.

INLAND WATERWAY TRANSPORT DEVELOPMENT IN ASSAM — LONG TERM STRATEGY

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ABSTRACT

The Brahmaputra River is precious gift of Nature to India especially to its northeast region; considering its vastness of water resources which the river basin possesses. Nearly 30% of India's water resources potential are found in this basin. In terms of the average discharge, the Brahmaputra River is the fifth largest river in the world. India's navigable inland waterways extend nearly 14,500 km, comprising a variety of river systems, canals, backwaters, creeks, and tidal inlets. Assam has a total of 1983 kmnavigable waterways, (about 14% of Nation's waterways). The Brahmaputra River has evolved in about two million years. Assam's trade with the neighbouring provinces, from very early times, was mainly carried by river transport, the main route to Bengal, Bihar and Orissa being the Brahmaputra and the Ganges. In 1834, when the steamer service was introduced on the Ganges, transport and communication to and from Assam, in general, were underdeveloped. The steamer service in the Brahmaputra, thereafter, between Calcutta and Guwahati (960 km), was established by the then Government in 1847. The Assam Rail Link completed in 1949. Apart from being one of the earliest modes of transport, the inland water transport is accepted as one of the most efficient modes of transport from the standpoint of energy consumption and environmental friendliness, world-wide. In the recent period, IWAI as well asNITIAayog,are putting their optimum thrust on the development of IWT.Today, Assam is having total 15 NWs, including NW-2, out of total 111 NWs of India.

EFFECT OF NON-SINUSOIDAL PITCHING PROFILES ON THE PROPULSIVE PERFORMANCE OF AN OSCILLATING FOIL

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ABSTRACT

By engineering standards, fish possess extraordinary swimming and maneuvering capabilities. It is interesting to understand how fish exploit the fluid around it to propel itself and from the application point of view, these studies will help to better design bio-inspired Autonomous Underwater Vehicles. Thrust generation from a flapping tail of a fish can be idealized by an airfoil undergoing pitching motion. Present work is an experimental investigation to study the effect of non-sinusoidal waveforms on the propulsive characteristics of an oscillating foil. We employ pitching motion of the desired waveform through a servo motor to a foil placed in a uniform freestream and record the unsteady forces and moments generated, using a loadcell. We compare the generated thrust, input power, and propulsive efficiency for three basic pitching waveforms, i.e. triangular, sinusoidal, and square-like waveform for a range of nondimensional pitching frequencies (Strouhal number). We are using two configurations for the foil, i.e. initially a rigid foil, and at a later stage by attaching a flexible flap at the end of its trailing edge. Hence chordwise flexibility is another independent parameter in this study. Results reveal that the square-like waveform produces higher thrust, whereas sinusoidal and triangular profile leads to better propulsive efficiency in case of both rigid and flexible foil.

APPLICATION OF ARTIFICIAL NEURAL NETWORK IN SILTATION STUDIES

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ABSTRACT

The Bay of Bengal is one of the most complex water systems in the world and so is its circulation and hydrography. This is mainly because of the semi-annual reversing monsoons and the associated heat and freshwater fluxes. Besides this, the inflow of warm saline waters of the Arabian Sea, the Persian Gulf and the Red Sea origin, and a number of synoptic disturbances (cyclones) originating during both pre-monsoon and post-monsoon period in this region, also affect the sediment dispersal pattern in the Bay of Bengal. Despite numerous studies and abundant literatures, the siltation rates of the Bay are not well estimated and is the motivation for the current work. Delft-3D is the most commonly used model to study the sedimentation along coasts. But we see that high errors are produced in the model as the distance from coast increases. This is because, these models simulate the tidal currents very well but do not consider the basin-scale circulation. In the far-shelf region (50m to 500m isobaths), there is a combined influence of tidal currents as well as basin scale velocity components. In this paper, as a solution to reduce the errors produced by the model, another method of determining the siltation rates is proposed, which is by using Artificial Neural Network (ANN). In this study, the ANN seems to provide a reasonable estimation of siltation rates considering the influence of both tidal velocity components and basin scale components along with surface elevation at deeper regions off the continental shelf.

A GEOSTATISTICAL APPROACH FOR CONTOUR MAPPING AND SPATIAL VARIABILITY OF GROUNDWATER IN AND AROUND ROURKELA, ODISHA, INDIA

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ABSTRACT

An investigation on groundwater assessment was done in Rourkela, lying between 84.54^0 E longitude and 22.12^0 N latitude located in the Sundergarh district of Odisha, India. A study of Geostatistical approach for contour mapping and spatial variability of groundwater in and around Rourkela city was attempted to discover the dominant processes in influencing the groundwater quality. The parameters used for this study were pH, Electrical Conductivity, Total Hardness, Sodium Absorption Ratio, Na %, Residual Soluble Carbonate, Residual Sodium Bicarbonate, Permeability index, Potential Salinity, Magnesium hazard, Magnesium/Calcium ratio, Kelley's ratio and indices of base exchange. Data plot dispositions on Gibb's diagram indicated that the chemistry of groundwater of the area is controlled by rock composition. Most of the samples with negative chloro-alkaline indices values suggested the predominance of chloro-alkaline disequilibrium process in the groundwater system. The contour mapping and spatial variability of the physico-chemical parameters suggests that the groundwater's of Chhend colony, Civil Township, Sector 21, Uditnagar and Bandamunda are most suitable for irrigation, in contrast to that of Koel Nagar, Shaktinagar, Basanti Colony and northweast part of Jagda-Jhirpani.

STUDY ON THE VULNERABILITY OF INDIAN WATER RESOURCES FROM THE ASPECT OF CLIMATIC UNCERTAINITY

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ABSTRACT

Much of the climatic change will be felt through changing patterns of water availability, with shrinking glaciers and changing patterns of precipitation increasing the likelihood of drought and flood. If climatic change is the shark, then water is its teeth and it is an issue on which businesses need far greater level of awareness". The effect of global warming further intensifies temporal and spatial variations in precipitation, melting of snow and water availability. The NASA ranked 2017 the second warmest year after 2016.Seventeen of 18 Earth's warmest years have been since 2001.Occupying 17.74 percent of the world's population, India is second only to China in terms of manpower. The hike in population and the rate at which water resources are polluted for industrial and economic development; there is a need to protect the available fresh water resources. The abnormal recurrence of floods in Kerala and the damage done by the Assam floods have given necessary alarms, highlighting the need to strike a balance between development and conservation. This paper aims at analyzing studies done previously on this topic, getting acquainted with the threats posed and arriving at possible solutions so that natural calamities can be prevented in the future.

CHARACTERISTICS AND VARIABILITY OF SEA STATE IN GULF OF MANNAR- AN ANALYSIS USING MOORED BUOY OBSERVATIONS AND MODEL RESULTS

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ABSTRACT

The sea state characteristics are decisive for everyone who ventures into the sea particularly for port operations. The satellite information and model results are less accurate, when it comes closer to the coastal area and necessitates measured data for accurate information. Gulf of Mannar occupies a strategic position and significantly impact socio-economic and political realms. The National Institute of Ocean Technology (NIOT) maintains the moored buoy network in the Indian Seas, in which two buoys were operational in Gulf of Mannar, one in Tuticorin Port limits and the other in offshore waters during the period 2000 to 2007. The measured wave data from these buoys are utilized in this study to estimate the characteristics and its variability in this region. The analysis of wave measurements from the moored buoys exhibit significant variability with calm sea conditions during pre-monsoon season followed by moderate to rough sea state during monsoon. The post monsoon season exhibits intermittent high waves associated with local weather systems. The southern ocean swells plays a significant role in the sea state in this region throughout the year. The numerical model results WaveWatch-III is also utilized to estimate the spatial variability of sea state characteristics. The study provides significant input in view of the recent trends in climate change and the associated changes in cyclone activity in this commercially active vessel traffic region.

ASSESSMENT OF ENVIRONMENTAL FLOW IN A HUMID TROPICAL BASIN USING HYDROLOGICAL METHODS

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ABSTRACT

Environmental flow is a key parameter to define the river health.The flow regime of a river should resemble its natural pattern so as to perform its functions such as maintaining ecological diversity, ground water recharge as well as supporting spiritual and cultural activities of the people. Among the various methods, hydrological methods are the most widely used techniques for the assessment of environmental flow. In the present study environmental flow of Pamba river basin, Kerala has been evaluated by the hydrological methods Tennant, Tessman, Flow duration curve analysis and low flow indices method.Tennant method and FDC Q95 recommends 54% of MAF as the required E-flow in the river, but it is 40% MAF for Tessman method. Flow corresponding to Q95 and Q90 are 14.23m^3/s and 16.42 m^3/s respectively from FDC analysis. Low flow indices are estimated for different return periods. Environmental flow assessment studies provide an insight in allocating the quantity of water in water resources management activities.

HIGH SPEED COASTAL PATROL VESSEL CUM EMERGENCY FLOOD RESCUE VEHICLE

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ABSTRACT

Coastal Security is of prime importance for a peninsula like India, whose sea borders extents upto a whopping 7512 km. A high speed vessel for emergency response in the coastal regions of India is therefore inevitable. The Indian coast Guard has lot of high speed vessels for this purpose, which ensures the coastal security. An ACV is proven to be good patrol vessel, given its maneuverability and ability to withstand wave slams even during a rough weather.

In recent days we have witnessed the devasting floods in the states of Kerala, Maharashtra, Karnataka, Assam etc. which claimed hundreds of innocent lives. From this fact we could learn that there is a huge scope of improvement in the present rescue and evacuation technique. So it is important to have a rescue vehicle which can be operated in both land and water. As air rescue operations are more expensive and rescue capacity is very less. The use of boats are not efficient in city areas and where water is less due to draft constraints.

Thus, we suggest a modified Air Cushion Vessel (ACV). This vehicle can be operated in both land and water. This can go up to 50 knots and can be used in any terrain. This vessel is having an endurance of 36 hrs. without any replenishments. It is powered by a gas turbine. This vessel also has a telescopic ladder on its side for rescuing people from tall buildings. This rescue boat will be under the combined custody of Indian Coast Guard and NDRF who is primarily responsible for encountering the natural calamities. The max crew is of 10 people and they will be experts in diving and survival techniques. 25 to 30 people can be evacuated at a time.A drone which is having a range of 15 km can be operated from the ACV. The drone will be fitted with heat sensing camera and phraselator. The ACV will be provided with basic life saving apparatus like life jacket, life buoys etc. In addition to this tinned food and water will be available in the vessel which would be sufficient for 30 people to survive for 04 days.

Natural calamities cant be avoided, but we can minimize the impact by proper planning and execution. This craft will revolutionize the rescue and evacuation operations during floods.

SMART JETTY

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ABSTRACT

The development of inland waterways created a necessity for the advancement of the jetty used. Presently, jetty which is present has a difference between the platform and deck of the vessel. Since there are no particular depth criteria for an inland vessel the difference in height varies. So it is1 needed to have a comfortable distance between the height of the deck and platform of the jetty. This can be compensated by this new concept of a smart jetty. This can be incorporated into any water body and can be started manually or automatically. The smart jetty is ballast tanks where water is stored in and valve to enable inflow and outflow of liquid. This ballast tank is controlled by a photodetector which analyses the depth of the vessel and adjusts its height according to it. This ballast tank is incorporated by a pump which pumps out water from the tank according to the requirement. Thus allowing the passenger to comfortably onboard the vessel.

RESURRECTION OF THE GEO-CHEMICAL MORPHOLOGY OF RIVER GANGUA TOWARDS ITS RESTORATION AS A RIVER FOR TOURISM AND FLOOD CONTROL

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ABSTRACT

Gangua once a historic river,takes on the load of the Bhubaneshwar city's domestic and industrial waste, which runs into it from the natural drainage channels. Without an operational sewerage system in the city, the water body has become a "living sewerage line'' for the city. There are more than 100 industries and two industrial clusters in the city, of which 34 are potential water polluters. They discharge their effluents into Gangua through the drainage channels.

Thus it is essential that gangua be restored to its original pristine glory and be used as a tourist resort on lines of those abroad as well as free it of its pollution and decimation which will enable flood control and water preservation.

The process proposed and needs to be implemented is a complex combination of dynamic water,soil,river course,sedimentation,subsoil hydrology evaluation combined with focussed dredging defined by aerial surveys,hydrology and bathymetric plans. This entire restoration plan is the subject matter of presentation

STABILIZATION AND SHIP MOTION SIMULATION USING WI-FI ENABLED AUTONOMOUS SHIP MODEL

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ABSTRACT

This paper reports a unique development in the national arena with regard to the hydrodynamic assessment of an oceanographic coastal research vessel for the National Institute of Ocean Technology, Ministry of Earth Sciences, Government of India. This paper focusses on two aspects of the study – free-running model simulations in the wave basin facility at IIT Madras and the performance assessment of the passive Anti Roll Tank (ART) stabilisation system. The paper describes practical deployment of the system in the laboratory with some sample results to highlight the new features of the developed system and the efficiency of the technique. The key development is the use of WiFi enabled (wireless) autonomous ship model in a simulated wave environment and the design of the controller based on system identification for the free-running model for simulation of all speed conditions in different wave headings. The passive ART system requires to be designed and verified for most favourable roll reduction. Analytically, the ship roll motion is characterized as a coupled system consisting of the ship system in waves and the oscillating fluid system in the U-Tube tank. This paper describes different experiments to establish the tank characteristics and damping of the ship roll motions through laboratory-scale simulations. Conducting free-running model tests, simulating the full speed of the vessel in any given wave direction and sea state, requires an active controller and integration of essential hardware elements in the model. Onboard data acquisition and wireless transmission to the shore base station, and closed-loop control of the rudder motor for effective directional control are some of the challenges in this development.

ADVANCED RADARS AND 5G TECHNOLOGY IN COASTAL SURVEILLANCE

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ABSTRACT

For a peninsula like India which has about 7516km of its border land shared with sea, coastal security is also a major significant factor to take into consideration for the protetion of the mainland. Most cargo ships that sail between East Asia, America, Europe and Africa pass through Indian territorial waters. According to the Ministry of Shipping (MoS), around 95% of India's trade by volume and 70% by value is done through maritime transport. Special economic zones (SEZs) are being developed in close proximity to several ports, thereby providing a logistical advantage to industries within these zones. The government has announced plans to develop 14 coastal economic zones (CEZs) in a phased manner for port-led development in all of the nine maritime states.

India's long coastline pose a variety of security concerns: • Landing of arms and explosives at isolated spots on the coast • Infiltration/ex-filtration of anti-national elements • Use of the sea and offshore islands for criminal activities • Smuggling of consumer and intermediate goods through sea routes, etc.

Today, emphasis is being placed on the costal security infrastructure in India; however, the threats to coastal security are varied and complex: • The remoteness of the vast coastline makes coastal areas susceptible as boats can land stealthily without being detected. • The creek areas of Gujarat and the Sunderbans are particularly vulnerable to clandestine activities as they are interconnected through small islands where mangroves and sandbars provide shelter. • Dhows (large wooden boats), which are extensively used for trade, are often involved in illicit trade and smuggling. • Fencing of land borders has increased infiltration through sea routes.• Unavailability of a monitoring mechanism to monitor coastal security across coastal states and union territories

Coastal Surveillance Systems (CSS) with integrated sensors and functionality toprotect borders, lifes, the environment and offshore critical assets. Radars design, build and integrate state of-the-art border surveillance systems for coastal supervision. These systems integrated with modern technology like 5G technology could help to make a major leap for coastal security services in India.

BIOMIMETIC PROPULSION SYSTEMS AND THEIR APPLICATIONS TO MARINE VEHICLES

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ABSTRACT

Imitation of models, systems, and elements of living beings in nature for effective utilization in human activities and related engineering applications is generally termed as biomimetics. Observations of highly-efficient swimming capabilities of aquatic animals have paved the way for studying oscillating foil as a propulsion mechanism for marine vehicles. This paper presents some of the biologically inspired propulsion systems and their applications.

NANO FUEL ADDITIVES: AN INNOVATIVE TECHNOLOGY FOR SHIP EMISSION REDUCTION

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ABSTRACT

One of the prominent issues that the world is confronting today is air pollution. Various innovative technologies are used to reduce emission and its harmful effect. The rapid growth of nanotechnology has gained a great deal of interest. Nano technology improves efficiency of the fuel which in turn enables reduced fuel consumption. In this paper various types of available nano fuel additives and their effective utility to minimize emission from ships are discussed. Use of nano adsorbent is an effective tool for the removal of NOx. 85% of nitrogen oxide emissions can be reduced using this technique. Some of the other application of nano materials viz., nano coating will reduce fuel consumption by 30%. A case study has been discussed in this paper elaborating how nanofuel is prepared and the same was tested in a research vessel. Emission data collected prior and post utilization of nano fuel to the engine was recorded using a portable flue gas analyzer and the data was validated by using both empirical method and a web tool emission calculator.

STUDY OF EFFICIENCY, PERFORMANCE AND RELIABILITY OF ORV SAGAR NIDHI USING GENETIC ALGORITHM

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ABSTRACT

Genetic algorithm is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution. Present study investigates use of genetic algorithm for improving engine efficiency and reliability of propulsion system of Oceanographic research vessel (ORV) Sagar Nidhi. Sagar Nidhi uses low sulphur high flash high speed diesel (LSHFHSD) as a fuel and specific fuel consumption at 1000 RPM is optimized. Fuel consumption is optimized for both in transit, maneuvering and dynamic positioning (DP) mode using genetic algorithm. Effect of genetic algorithm in reducing failure rate and improvement in reliability is explained in detail.

PROJECTION OF WAVE CLIMATE INTO THE FUTURE DUE TO CLIMATE CHANGE

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ABSTRACT

The study of wind and wave climate in the Bay of Bengal region is necessary to decide on the important coastal activities as most of the population lives along the east coast of India. The wind and wave characteristics of severe cyclonic storm Vardah which occurred in the year 2016 have been chosen for the present study to project for different Representative Concentration Pathway (RCP) scenarios RCP4.5, RCP6, RCP8.5 for Near-Future (2035) and Far-Future (2075) categories. The waves were simulated using the WAM (Wave Analysis Model). The surface wind above 10m height is obtained from the WRF (Weather Research Forecasting) model which is then forced into the WAM model to predict the wave climate. The significant wave height (Hs) obtained for the Far-future case of RCP8.5 is found to be higher compared to all other cases.

REVIEW OF COASTAL SURVEILLANCE REQUIREMENTS AND POSSIBLE SOLUTIONS FROM THE SECURITY PERSPECTIVE

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ABSTRACT

The Indian Peninsula surrounded by the Arabian sea, Indian Ocean and the Bay of Bengal with its long coast line is a very unique eco system with many features. The climate, the marine life, presence of large number of offshore installations and the proximity to shipping lines of commerce etc are all important and has to be continuously monitored and protected. The vast coast line comprising more than 7500 km needs to be continuously monitored from the security point of view. The paper attempts to identify the requirements for integrated surveillance of the vast coast line from the security perspective and review available technologies for local and integrated surveillance solutions. The major stake holders, their roles and the need for a synergetic approach is also elaborated. The paper also identifies focus areas for study and research to achieve effective coastal surveillance.

3-D MARINE WEATHER FORECAST DISSEMINATION SYSTEM – PANORAMA

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ABSTRACT

Indian Navy undertakes wide variety of operations on different scale of time and space across the globe. This broad continuum of operations is scaled down into distinct roles, each demanding a specific approach to the conduct of operations in contrast to commercial maritime activities wherein the weather information is primarily used for safe and economical navigation. To meet these specific Op driven requirements, **Panorama, a marine weather decision support system has been developed. It is a 'Make in India' initiative**. This GIS based software is an engine to process and visualize observational and forecast data at both ground stations and onboard ships in all the three dimensions of the operating environment, viz., surface, sub-surface and air. This is a complete automated system which has real time data download from multiple sources, database management, multi-parameter visualization, extreme event analysis, alerts and real time data dissemination to ships sailing across the globe with voyage planning support. It has the state of the art data compression.

PARADIGM SHIFTS ESSENTIAL FOR RESTORING WATER HEALTHIN INDIA

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ABSTRACT

India with less than 2.4% of the global land area enjoys sizable 4% share of global freshwater resource. Our 200 nautical mile-limit exclusive economic zone (EEZ) adds23.06 million sq. km equalling 1.6% share in world's ~1372 million sq. km EEZ area. This implicitly good feeling wanes rather distastefully when the fact of the worst water quality index mocks us. Such poor-qualityindex ranks us near-bottom at 120th of 122 nations reviewed. We are the third largest groundwater extractors, although being blessed with some very high rainfall regions. From pristinely pure in rain drops or in the upper reaches of high Himalayas (plus some mountains) our pan-India water bodies are extremely toxics-amalgamated-slurries in many of our heavily industrialised locations and, numerous overly crammed urban settlements lacking adequate wastewater treatment, management or recycling practices. Due to direct open dumping, prolonged open stagnation, natural lakes and rivers are mute receptacles for all sorts of wastes. Our water ways indeed are filth-drains across this vast nation. In view of this, there is an urgentand serious need for revitalizing existing policies for sustainable ecological harnessing, and benefiting economically by keeping our aquatic bodies clean, healthy and pollution-free. Further, keeping our seas clean and healthy are pivotal for blue economy prospecting through marine aquaculture, marine chemicalsand freshwater generation among others. In view of these, strict implementation of available national water conservation and protection policies and, steps mandatory for improving and upkeeping water health are putforth.

THE IMPACT OF SEASONAL AND SPATIAL CHANGES IN THE LAGOONAL WATER CHARACTERISTICS ON THE BENTHIC FORAMINIFERA

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ABSTRACT

The lagoonal lake water characteristics significantly change due to freshwater influx from the continental rivers and seawater influx from the seasidethat makes a unique transitional system. This study aims to assess the impact of seasonal and spatial changes in lagoonal water characteristics on the benthic foraminifera. Sediment and water samples were collected during three different seasons viz., September (SWM), January (NEM),and May (PSWM) from 22 fixed stations of Chilika Lake spreading from freshwater to saline water end. Physicochemical parameters of the lake bottom water were determined in-situ. The data suggest that the lake water changes from fresh to marine in different seasonsand supportthree diverseecosystems. The benthic foraminifera abundances and diversity in the lake bottom sediment are found more responsive towards the spatial variation in comparison to the seasonal changes in the lake. The freshwater ecosystem near the river mouth does not support brackish water benthic fauna. Interior lake with brackish water ecosystem promotes the flourishing of calcareous *Ammonia* genus of benthic foraminifera. However, the abundance of trace elements (Cr, Cu, Pb, and Zn) creates a stress conditionthat causesthe small size and short life span of foraminifera. The brackish to marine ecosystem near the sea mouth supportsdiversification of benthic foraminifera marked by the presence ofboth calcareous and agglutinated species, but higher energy conditions constrained their abundance and may cause morphological abnormality in the shells. This study suggests that both seasonal and spatial changes in the sediment flux and bottom water chemistry have an essential role in benthic foraminiferaecology and population abundance in the coastal lagoons.

CAPACITY AND MANOUEUVERING OF INLAND VESSELS IN RIVERINE WATERWAYS

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ABSTRACT

The transportation by water is the cheapest mode of transport as compared to road and railways on ton per km basis. Waterway freight can further be reduced by harnessing economies of scale vessel that is optimally fit for the waterway like the Panamax and Suezmax vessels. The sizeof these vessels is limited by width and depth of the canal or dimension of the navigation lock. In case of riverine waterways with serpentine channels, strong currents and shallow water effects, controllability of Inland Vessels is a major factor that determines optimal capacity of the vessel by limiting the length of vessels. The vessels that traditionally ply in National Waterways in India carry conventional flat plate rudders and fixed pitch open propellers. The factors on inland ship manoeuvres that correspond to limited channel breadth and shallow water were more or less ignored in initial ship design. The paper analyzes how the dimensions of waterways are interlinked with manoeuvering characteristics and size of inland vessel. It identfes the navigation tests to be conducted to determine manoeuverability of Inland Vessels. Based on the Design Guidelines for Inland Waterway Dimensions(PIANC, 2019), the critical bends on National Waterway-1 have been identified.Thereafter as part of the ongoing thesis on “Improving Manoeuverability of Inland Vessels in Riverine Waterways” at IMU, adetail field study to be conducted on inland cargo vessels to determine how by improving the maneuverability the carrying capacity may be increased. The critcal bends identified in the paper to be used for field study on manoeuvrability of the Inalnd Vessel.

REDUCTION OF CARBON FOOTPRINT AND OPERATING COSTS OF VESSELS OPERATING IN INLAND WATERWAYS BY REDUCING FRICTIONAL RESISTANCE

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43497-F, Indian Navy

ABSTRACT

India has an extensive network of inland waterways in the form of back waters, canals, rivers etc. with a total length of about 14,500 Kms of which about 9200 Kms can be used by mechanised vessels. The total weight of cargo transferred through these motorised vessels this year amounts to 72 Million tonnes and the Indian Government aims to increase this quantity to 120 Million tonnes by 2023. This would need an augmentation in the number of vessels and the infrastructure of National Waterways. All the inland vessels transporting cargo, passengers and undertaking other functions have a certain carbon foot print and operating cost. Even a fractional reduction in the operating cost and carbon footprint of these vessels would add up to a large amount when seen on the national scale in terms of National Carbon Footprint reduction and the benefit to the national economy. This paper aims to devise a method to further reduce the frictional resistance of the vessels thus achieving reduction in Op. costs and Carbon footprint. This paper deals with a study on a specific method of installation of polyolefin-based paint protection films to the underwater hull to reduce the frictional component of resistance and brings out the tangible benefits in terms of cost and environmental protection accrued from this method.

ASSESSMENT OF IMPACTS OF CLIMATE CHANGE ON STREAMFLOW USING HEC-HMS: CASE STUDY OF KESINGA WATERSHED, ODISHA

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ABSTRACT

Hydrological modeling of watersheds coupled with simulations of projected future climate from general circulation models (GCMs) and regional climate models (RCMs) isbeneficial for the study of impacts of climate change on hydrologic variables at watershed scale. Owing to climate change, the hydrological response of watersheds and the streamflow pattern could significantly change, leading to erratic extreme events such as floods and droughts. In this study,continuous modeling approach throughthe popular hydrologic model HEC-HMSis carried out to simulate the water balance of Kesinga watershed in Mahanadi river basin, Odisha, India. The developed hydrological model for Kesinga has R^2 value of 0.74 and 0.62 during calibration and validation respectively. Future climate projections corresponding to the representative concentration pathway (RCP) 8.5 scenario from the RCM COSMO-CLM model of the CORDEX areutilized for simulating the future streamflow after suitable bias correction. Climate change impact assessment on future streamflow is performed for two future periods: 2041-2070 (F1) and 2071-2100 (F2).Results from the study suggest that changes in streamflow pattern are possible due to potential future climate change.In general, average monthly flows are found to decrease in future when compared to baseline period. On the other hand, magnitude of peak flows are found to increase in futurein this watershed. The results of the study emphasize the need for climate change impact assessment studies at watershed scale for water resources management under potential future climate change.

Membership Application Form

FORUM FOR RIVER AND OCEAN SCIENTISTS AND TECHNOLOGISTS

(Attach passport size photograph)

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Phone no.:

Mobile no.:

Educational Qualifications (degree, University, year):

Membership of other Societies:

Any other information:

Proposed by (must be by an existing member) including signature:

Seconded by (must be by an existing member) including signature:

[Note: Membership fees will be intimated in due course]

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RESEARCH VESSELS OF NIOT, MOES

Ministry of Earth Sciences
Government of India

SAGAR NIDHI

Sagar Nidhi is India's pride and a state of art ice-class research vessel of the sub-continent. Ship is equipped with sophisticated facilities onboard to carry out ocean exploration & technology demonstration on par with world class standards.

PRINCIPAL PARTICULARS

Name	- SAGAR NIDHI
Length Overall	- 103.6 m
Breadth moulded	- 18 m
Draught	- 4.2 m
Gross Registered Tonnage (GRT)	- 4862 MT
Main Engine	- 4x1440kW
Speed	- 14 kt
Endurance	- 45 Days
Scientists	- 30
Officers & Crew	- 25
Type	- DP II, Ice Class-1C
Classification	- DNV & IRS
Shipbuilder	- Fincantieri, Italy

SAGAR MANJUSHA

SAGAR PURVI

Sagar Manjusha & Sagar Purvi are real work horses of MoES, being utilized by various National Labs, Academic & Research institutes, universities involved in ocean and allied sciences extensively.

PRINCIPAL PARTICULARS

Name	- SAGAR MANJUSHA
Length Overall	- 60.0 m
Breadth moulded	- 11.0 m
Draught	- 3.0 m
GRT	- 1065 MT
Main Engine	- 2x578 kW
Speed	- 11.5 kt
Endurance	- 20 Days
Scientists	- 11
Officers & Crew	- 18
Classification	- IRS
Shipbuilder	- HSL, Vizag

PRINCIPAL PARTICULARS

Name	- SAGAR PURVI
Length Overall	- 30.15 m
Breadth moulded	- 11.0 m
Draught	- 1.96 m
GRT	- 187 MT
Main Engine	- 2x105 kW
Speed	- 8 kt
Endurance	- 10 Days
Scientists	- 6
Officers & Crew	- 8
Classification	- IRS
Shipbuilder	- Corporated Shipyard, Kolkata

NEW COASTAL RESEARCH VESSELS-CRV SAGAR TARA & SAGAR ANVESHIKA

As part of augmenting Coastal and Oceanic research capabilities of the country a New Coastal Research Vessel, Sagar Tara has been acquired by NIOT, Chennai for the Ministry of Earth Sciences, Govt. of India at M/s TWL shipyard, Kolkata on 16th August, 2019. Another identical vessel Sagar Anveshika was successfully launched on 31st August, 2019 & scheduled to be delivered by February, 2020.

PRINCIPAL PARTICULARS

Length Overall	- 43 m
Breadth moulded	- 9.6 m
Draught	- 2.5 m
GRT	- 497
Main Engine	- 2 x 552 kW
Speed	- 12 knots
Endurance	- 15 Days
Scientists	- 8
Officers & Crew	- 12
Type	- CRV
Classification	- IRS
Shipbuilder	- TWL Shipyard, Kolkata

VESSEL MANAGEMENT CELL, NIOT, MOES, CHENNAI