SUPREME AUDIT INSTITUTION OF INDIA
लोकहितार्थ सत्यनिष्ठा
Dedicated to Truth in Public Interest

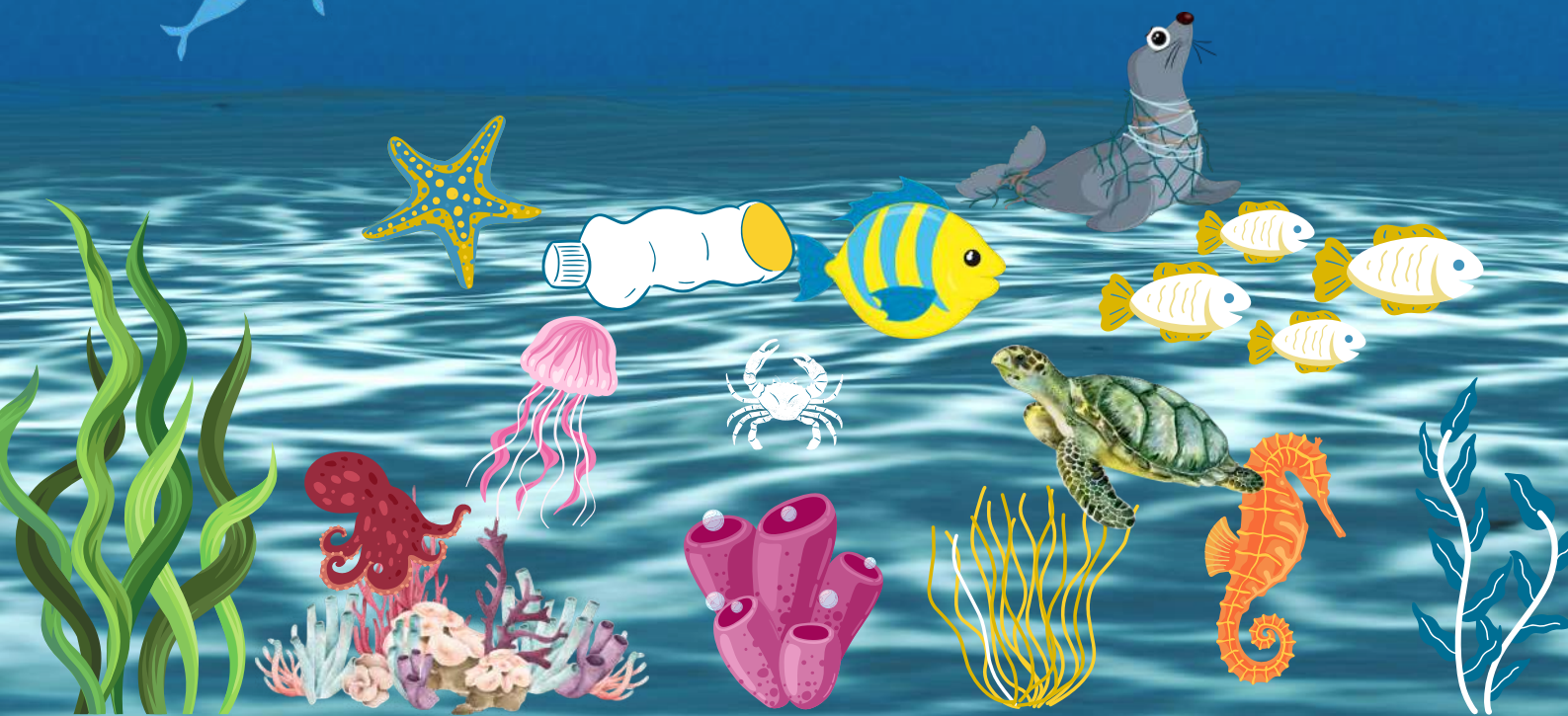
iCED

GREEN FILES

iCED's Quarterly Journal

Volume-47

Perspectives on the Blue Economy



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Acknowledgement

We thank all the contributors for their immensely valuable contributions and for making this endeavour a success.

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FOREWORD

In this 47th volume of the "Green Files", iCED's quarterly journal, we enhance with zest, vigour and elan on the content of our 45th and 46th volumes with a further focus on the Blue Economy. As in every issue, iCED, under the aegis of the Comptroller and Auditor General (C&AG) of India, attempts to highlight both local and global issues, involving environmental audit and sustainable development. The emphasis on the "Blue Economy", is in tandem with the SAI20's focus on this topical area and in keeping with iCED's constant endeavour to strengthen and value-add to SAI India's knowledge-sharing networks.

This edition has highlighted multiple sectors and perspectives in auditing the Blue Economy in India. The article titled "Conservation of Sea Cows (Dugongs) and their habitat in India" sheds light on the ecological significance of sea cows, the challenges they face, and the conservation initiatives undertaken to ensure their survival.

The article on "Floating Solar Farms: An innovative approach to maximise solar energy generation" delves into innovative renewable energy solutions, specifically the floating solar farms, and their potential to maximise solar energy generation. We continue some of our earlier features such as a State-Centric article. In this issue, we focus on the State of Himachal Pradesh, providing directions in audit planning to map plausible areas for environmental audit.

We again feature book reviews to familiarise readers with the corpus of environmental research. The book review on "Marine Pollution And Human Health" edited by R. E. Hester and R. M. Harrison, provides significant and valuable understanding of the interaction between marine environment and human health, from the perspectives of natural land-based, oceanic, and anthropogenic processes. Another book review titled "Renewable Energy and Energy Conservation" by Dr. V. Kirubakaran and Dr. R. Seerangarajan brings forth a comprehensive exploration of renewable energy sources and energy conservation strategies, particularly in India by focusing on different aspects of renewable energy and its applications.

Additionally, the edition includes a featured article, from a leading national think-tank on the Blue Economy, the National Maritime Foundation (NMF). The article titled, "Towards a Sustainable Blue Economy: Incorporating Green Norms in Ships' Underwater Hull Protection Practices in India", written by Ms. Ayushi Srivastava and Commodore Debesh Lahiri has been reprinted with kind permission from the NMF.

The journal further covers a gist of the trainings/workshops/other activities conducted at iCED and recent happenings in SAI India and INTOSAI WGEA community during the period July-September 2023. To engage our readers' interest and increase their environmental awareness, we have continued to feature a "Cross Word", like in the previous editions.

We have in this issue showcased selected Audit Reports relating to the Blue Economy and new energy sources, of both a national and international nature. ***Special Report: 2020 Marine environment: EU protection is wide but not deep*** *delves into important aspects: the protection of marine biodiversity, spanning from the adoption of the Marine Strategy Framework Directive (MSFD) in 2008 to March 1, 2020.*

A list of References is included in this journal to provide detailed reading material on the featured themes. We have continued with our publications under the "Occasional Research Paper (ORP) Series". One ORP relating to Plastic Waste was published recently on iCED's C&AG website. The links to these articles are available in the "Research" section under the title "Occasional Research Paper Series" on the website of the iCED (www.iced.cag.gov.in). The iCED website also has links to all iCED research publications to act as a repository of knowledge and documentation in an ever-evolving and interconnected domain such as environment audits and sustainable development issues..

On behalf of the entire team of "Green Files" at iCED, we strive to showcase various environmental issues and look forward to your suggestions to make Green Files as informative and user friendly as possible. Your contributions within the broad scope of this quarterly journal will be highly appreciated, including any feedback you may like to share on the featured articles.

17th January 2024
Jaipur

(Sayantani Jafa)
Addl. Dy. C&AG and Director General, iCED

Message of Director (Training and Research)

iCED's quarterly journal "Green Files" provides a window to the issues involving environment and sustainable development, from the perspectives of public sector auditing. In this endeavour, glimpses of developments in capacity building activities and research undertaken at iCED are highlighted. This 47th volume of "Green Files" brings out, inter alia, book reviews, articles, news items highlighting multiple dimensions of Blue Economy and recent environmental issues of interest, to help understand these dimensions, from the focal point of Audit.

During the last year, our primary focus has been on the sectors of Blue Economy, as has been evident in our national and international training programs, research initiatives, publications, and the different volumes of our quarterly journal "Green Files". The 47th edition of the Green Files also revolves around the theme of Blue Economy, featuring 15 articles contributed by the IA&AD officials and Research Associates at iCED, along with one article reprinted with kind permission from the National Maritime Foundation's archive. While all these articles are directly related to the Blue Economy sectors, each article differs in their focus areas, such as linkage of Blue Economy to the Sustainable Development Goals of United Nations, national maritime policy and international laws related to marine issues, how coastal communities show resilience towards Climate Change, benefits of floating solar farm etc.

We hope that this edition will prove to be valuable in enhancing comprehension of the diverse facets of the Blue Economy, especially for their relevance to the auditing professionals.

Dr. Nanda Dulal Das
Director (Training and Research), iCED

TABLE OF CONTENTS

01 *SAI India/iCED News*

INTOSAI WGEA News 24

26 *Book Review: Marine Pollution and Human Health*

Book Review: Renewable Energy and Energy Conservation 31

35 *Blue Economy and Sustainable Development Goals: A Review Article*

Towards a Sustainable Blue Economy: Incorporating Green Norms in Ships' Underwater Hull Protection Practices in India 38

57 *Climate Change Resilience in Coastal Communities in India*

Blue Economy 64

71 *Floating Solar Farms: An Innovative Approach to Maximise Solar Energy Generation*

How Marine Protected Areas Are Central to Our Blue Economy? 76

81 *Special Report 2020, Marine Environment:EU Protection is wide but not deep*

Innovation and Empowerment in Blue Economy – From Underrated Ecosystem to Sustainable Industry 86

90 *Conservation of Sea Cow (Dugongs) and Their Habitat in India*

Maritime Security and Blue Economy- Interdependency in The Indian Ocean 94

101 *State in Focus - Himachal Pradesh*

109 *Cruise Tourism and Need for Sustainability in the Marine Tourism Sector*

Green Hydrogen Policy and Global Efforts to Produce Green Hydrogen as a Clean Source 114

123 *Algae Bloom as a Major Threat to Fisheries, Economy, and Public Health*

Blue Economy, the Driving Force of India's Current Diplomatic Policy 129

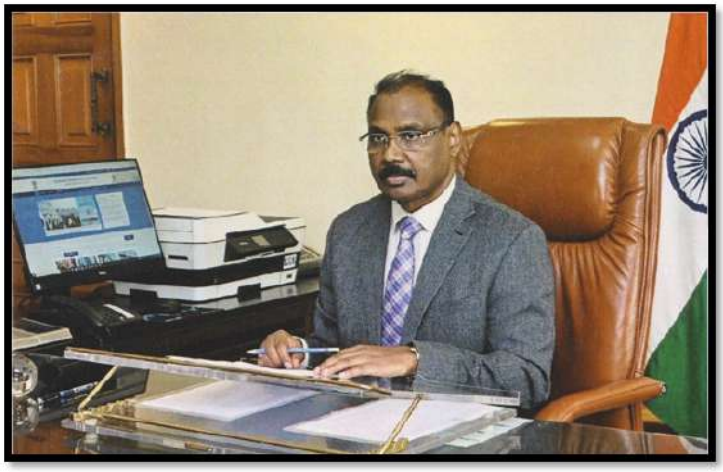
133 *Ocean Acidification as a Threat to Marine Life*

Birds at ICED 138

141 *Cross the Blue Word*

Occasional Research Papers 144

By: Kailash Chand Bajya, AAO



Hon'ble C&AG of India,
Shri Girish Chandra Murmu

C&AG/iCED/INTOSAI WGEA/ASOSAI activities (July to September 2023)

The 59th Governing Board meeting of the Asian Organisation of Supreme Audit Institutions (ASOSAI) was held in Busan, Republic of Korea from 20th to 22nd September 2023 (C&AG of India 2023). Shri Girish Chandra Murmu, the Comptroller and Auditor General (C&AG) of India and a permanent member of the ASOSAI Governing Board attended this meeting and advocated for the establishment of a Working Group on IT Audit and Data Analytics within ASOSAI (C&AG of India 2023). .

On the side-lines of this meeting, he also engaged in bilateral discussions with Dr. Hussam Abdulmohsen Alangari, President of the General Court of Audit (GCA), Kingdom of Saudi Arabia, and Ms. Datuk Wan Suraya Wan Mohd Radzi, Auditor General of Malaysia for enhancing bilateral relations and fostering collaboration between SAIs.

Shri Murmu also held bilateral meetings with Mr. Gamaliel Asis Cordoba, Chairperson of the Commission of Audit, Philippines on September 15th to 16th, 2023 (C&AG of India 2023). They discussed a wide range of areas for cooperation, specifically in the fields of Citizens' Participation in Audits, Audit of Public Debt and Use of Information Technology in the Auditing process.

C&AG of India bags highest Hindi Award; Rajbhasha Kirti Puraskar

Hon'ble C&AG of India
Shri Girish Chandra Murmu

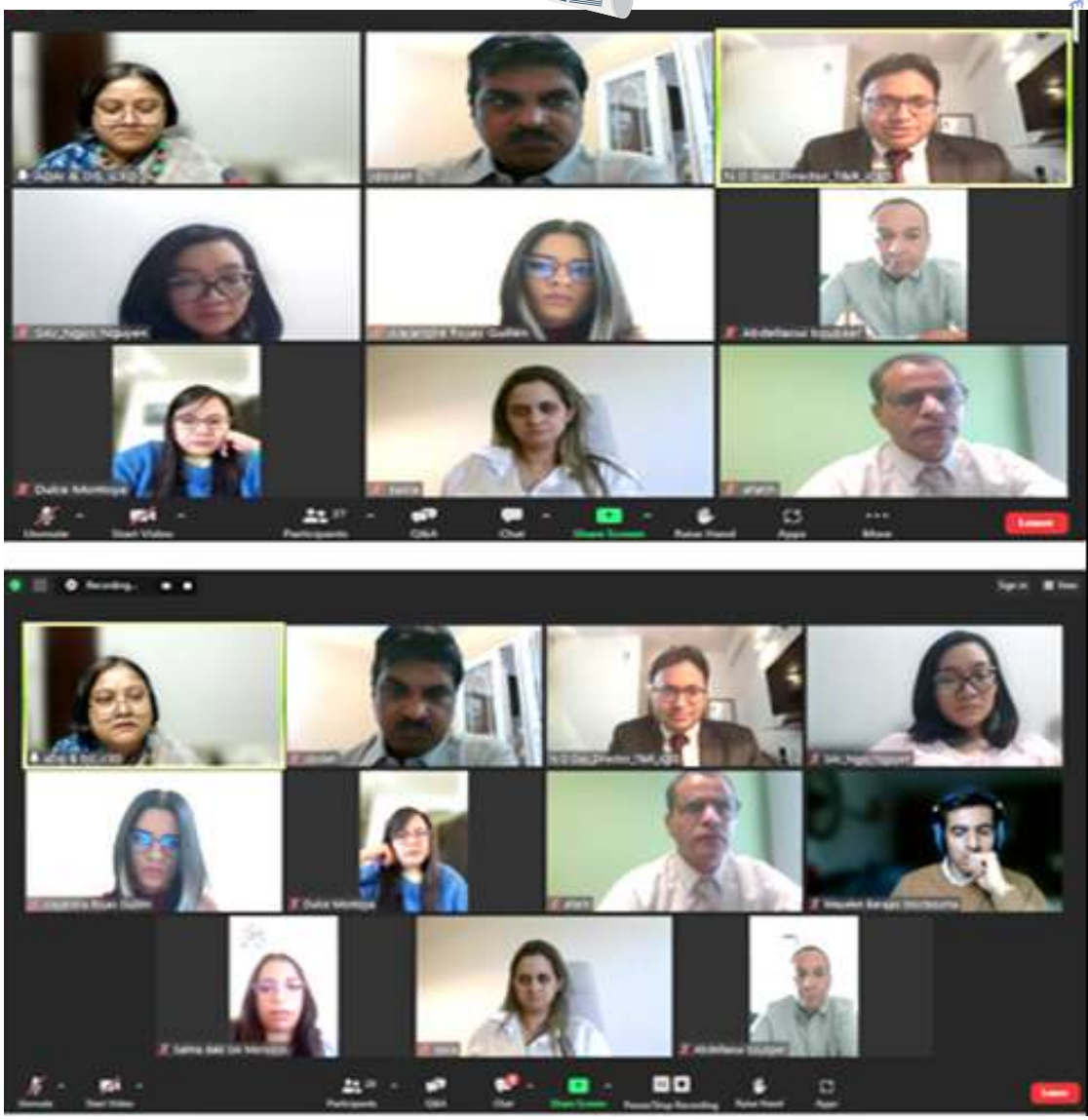
The Office of the Comptroller and Auditor General of India has been conferred with the highest award **"Rajbhasha Kirti Puraskar",** by the Ministry of Home Affairs, Government of India for the best implementation of Rajbhasha Policy (in the category of Department with more than 300 personnel for the year 2022-23). The award was presented by the State Home Minister to the Director General (Rajbhasha) of C&AG office in Pune (Maharashtra) on 15th September 2023 (C&AG of India, 2023).

9th ASOSAI Seminar on Environmental Auditing

The 9th ASOSAI Seminar on Environmental Auditing and the 9th Working Meeting of ASOSAI WGEA was held in Astana, the capital of Kazakhstan, from 23rd to 25th August 2023. During this event, the Second ASOSAI Green Vision Award was given to the Audit Board of the Republic of Indonesia (CNAO China 2023).

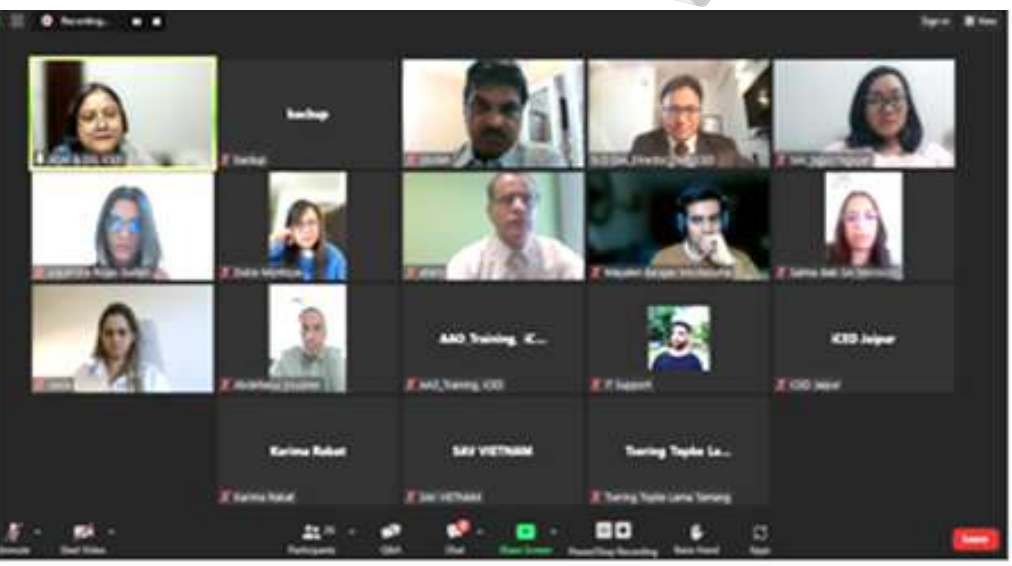
9th ASOSAI Seminar on Environmental Auditing Image Source : (CNAO China 2023)

Dr. Nanda Dulal Das, Director (Training and Research), iCED Jaipur represented SAI India in this seminar and gave a presentation on topic "Responding to Climate Change and Environmental Protection Audit: Experiences from Steel Plants and Waste Management Audits".



Attendees participating in "Multidimensional Aspects

During the period July-September 2023, International Centre for Environment Audit and Sustainable Development (iCED) as the Global Training Facility (GTF) of INTOSAI Working Group on Environmental Auditing (WGEA) organised two International Webinars on "Multidimensional Aspects of Auditing Blue Economy" and "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14", one National Workshop on "Climate Change with reference to Marine Ecosystem, Biodiversity Loss and Marine Pollution" and four National Training Programmes (NTPs) on the themes of Blue Economy and Climate Change. Details of the Training Programmes/Webinars are summarised below:

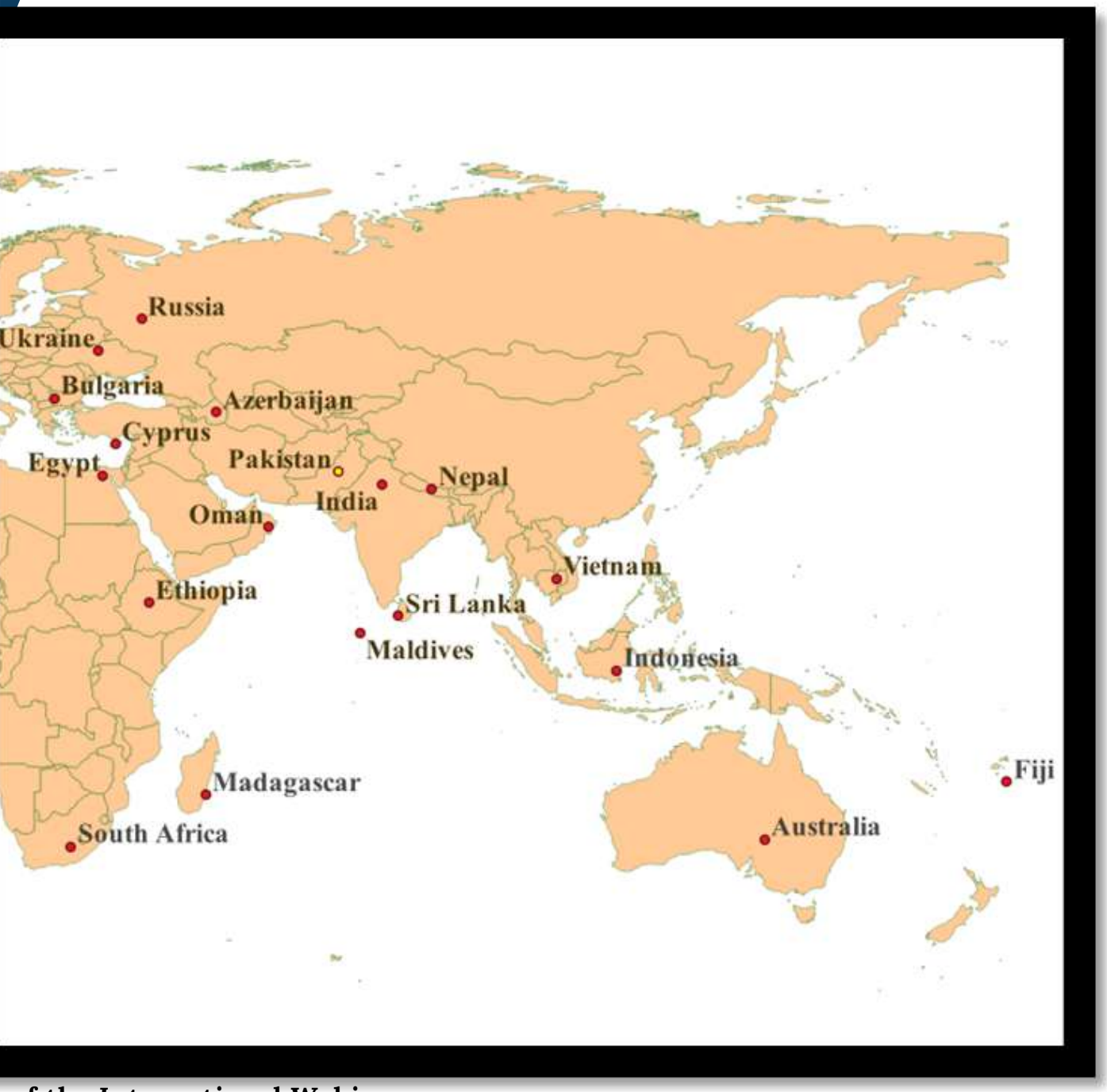


International Webinar on
of Blue Economy" on 14th July 2023

International Webinar on "Multidimensional Aspects of Auditing Blue Economy" (13th and 14th July 2023)

The Webinar on "Multidimensional Aspects of Auditing the Blue Economy" was conducted in two groups as per time-zone requirements. First group consisting of 38 participants and the second group of 26 participants from 21 SAIs participated in virtual mode on 13th and 14th July 2023 respectively.

Map representing 21 SAI's participants (in Red colour),
Webinar,
13th and 14th July 2023



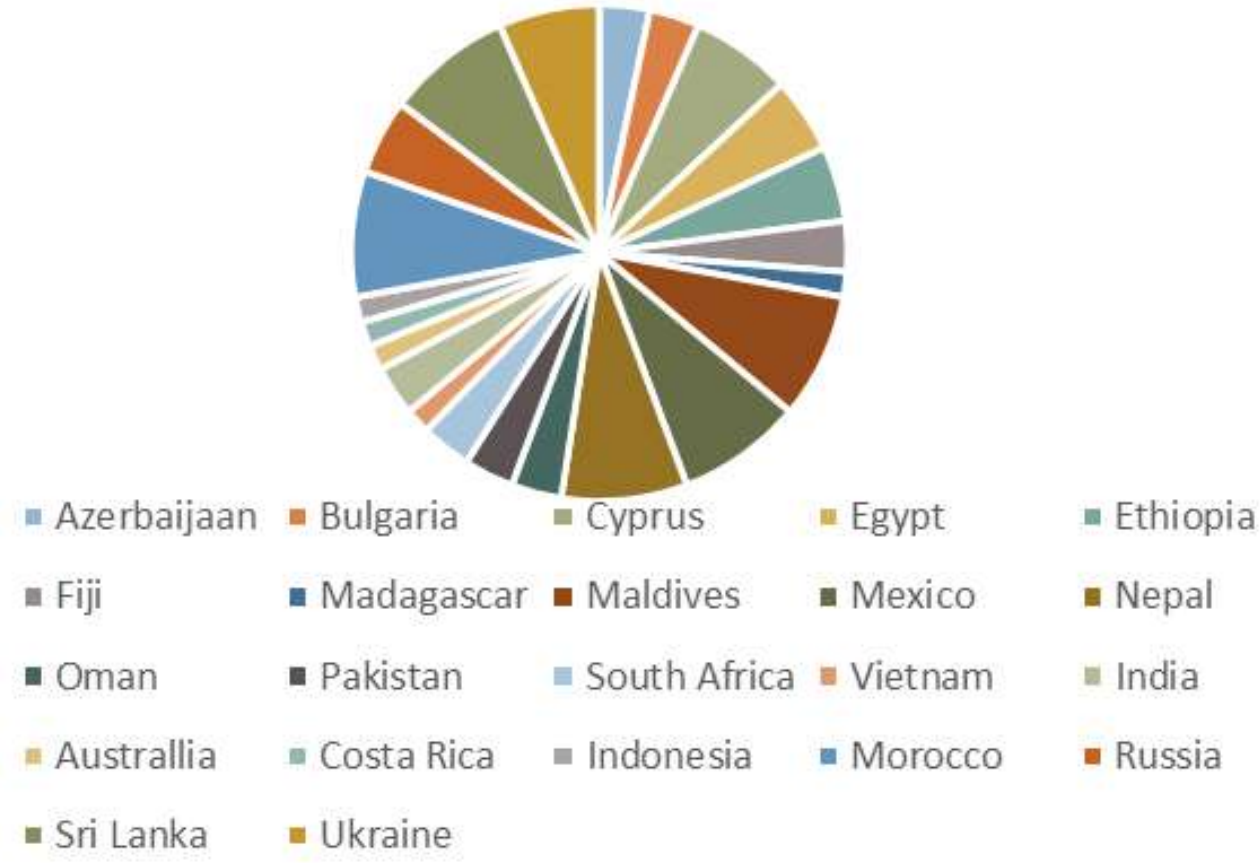
of the International Webinar,

Ms. Sayantani Jafa, ADAI and DG, iCED addressing the participants during Inauguration of the International Webinar (Batch I and II), July 2023

Ms. Sayantani Jafa, Additional Deputy Comptroller and Auditor General and Director General, iCED inaugurated the Webinar on both the days. She highlighted that Sustainable Blue Economy offers solution to numerous challenges posed by Climate Change and resource extraction, by promoting development of ocean resources in a fair and equitable manner.

Ms. Jafa mentioned that globally the Blue Economy can play a crucial role in mitigating the impacts of Climate Change. For example, renewable energy generation from offshore wind, wave, and tidal power can help reduce greenhouse gas emissions and promote a shift towards a more sustainable energy system. Further, the ocean acts as one of the largest carbon sinks in the World, warming of which can further threaten the progress made so far in climate-change mitigation commitments. Before closing, she thanked Mr. Sami Yläoutinen, the Auditor–General of Finland and Chair of INTOSAI Working Group on Environmental Auditing and his team from the National Audit Office (NAO), Finland, for their support in organising this Webinar.

Participants Countries who participated in the International webinar on 13th July and 14th July



Participants and Foreign Faculties during Sessions conducted in International Webinar on "Multidimensional Aspects of Blue Economy", 13th and 14th July 2023

Participants and Foreign Faculties during Sessions conducted in International Webinar on "Multidimensional Aspects of Blue Economy", 13th and 14th July 2023

Faculties delivering Sessions during International Webinar on Multidimensional Aspects of Blue Economy

Prominent foreign faculties who addressed the Webinar on the theme of Blue Economy included Ms. Jacqueline Hedditch, Senior Director of Performance Audit at the National Audit Office (NAO), Australia on "Audit of Regulation of Great Barrier Reef Marine Park Permits and Approvals by NAO Australia: Experience Sharing", Mr. Jonathan Dent, representing the Government Accountability Office (GAO) US on "Audit of Ocean Acidification: Experience Sharing by SAI USA", and Mr. Juihendranath Dodah, Assistant Director of Audit at NAO, Mauritius on "Performance Audit of Moving towards Sustainable Artisanal Fishery in Mauritius: Experience Sharing", Mr. Fraddry D'Souza, an independent researcher and former associate of The Energy and Resources Institute (TERI) India, Commodore Debesh Lahiri from National Maritime Foundation, Ms. Aditi Sharma from SAI India, Dr. Kathiresan Kandasamy, Professor at Annamalai University, Tamil Nadu were the Indian faculty members.

Valediction of the International Webinar on "Multidimensional Aspects of Auditing Blue Economy"

Ms. Sayantani Jafa, ADAI and DG, iCED during the valedictory session thanked the participants for their active participation in the programme so that the programme could be conducted successfully. She stated that the Blue Economy is a labyrinthine and multifaceted area which is driving

economic growth and innovation. Its vital importance is thus opening up new frontiers for auditing, and the need for upscaling capacity building and research has thus formed a key theme of the SAI20 Engagement Group under the chair of the Hon'ble Comptroller and Auditor General of India, Shri Girish Chandra Murmu.

She stated that the sharing of experiences and perspectives during the webinar would suitably equip all the participants to take the learning process forward. She expressed her gratitude to all the resource persons for sharing their experiences with the participants. She also thanked all the SAIs who had nominated resource persons to deliver the sessions during the webinar. Dr. Deen Dayal Verma, Director (Administration), iCED and Dr. Nanda Dulal Das, Director (Training and Research), iCED conveyed vote of thanks to all the faculties for sharing their knowledge and experiences during Batch I and II respectively.

We are greatly encouraged by the positive feedback on the sessions:

"It was a very good webinar; you gave us important examples and many tools that can be implemented".

Mr. Roberto Ezquivel from SAI Mexico

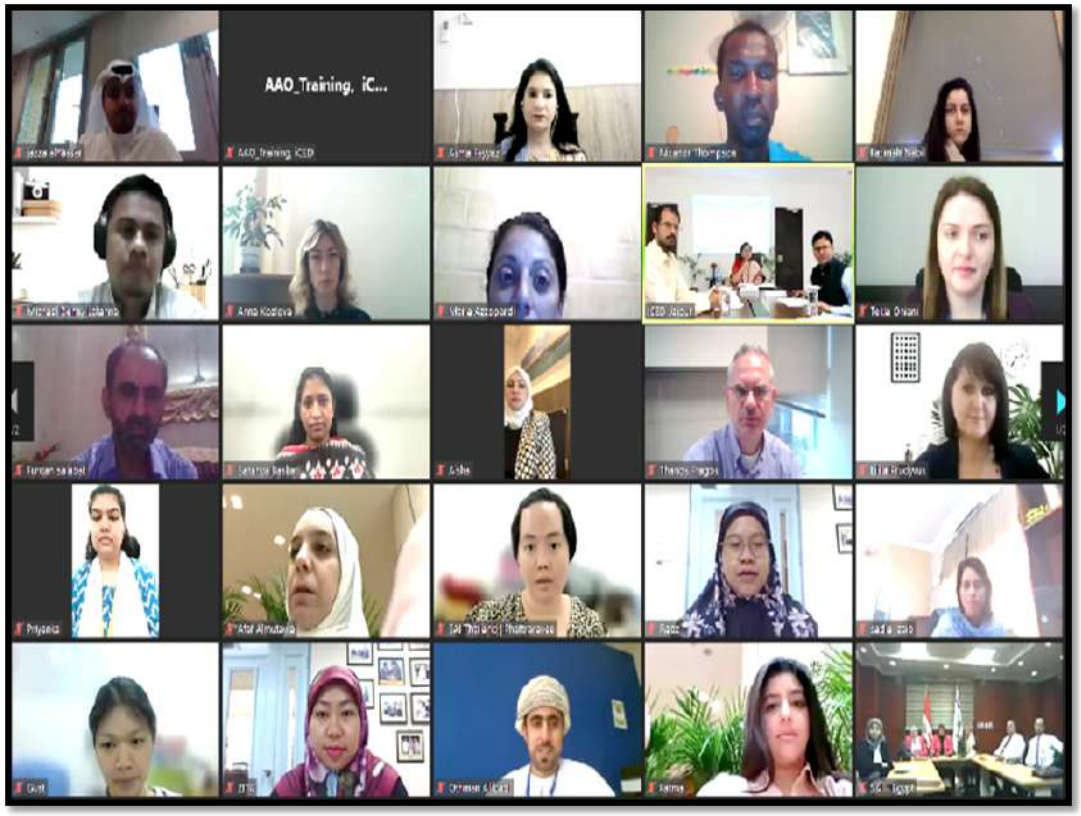
"It was a well managed seminar, very good. Keep it up".

Mr. Loknath Ghimire from SAI Nepal

"The topics were very well presented with lot of insights and capacity development on the overview of Multidimensional Aspects of Blue Economy. Greatly appreciated and blessed to be part of this wealth of knowledge transmissions".

Mr. Lote Rokoli Naicavu from SAI Fiji

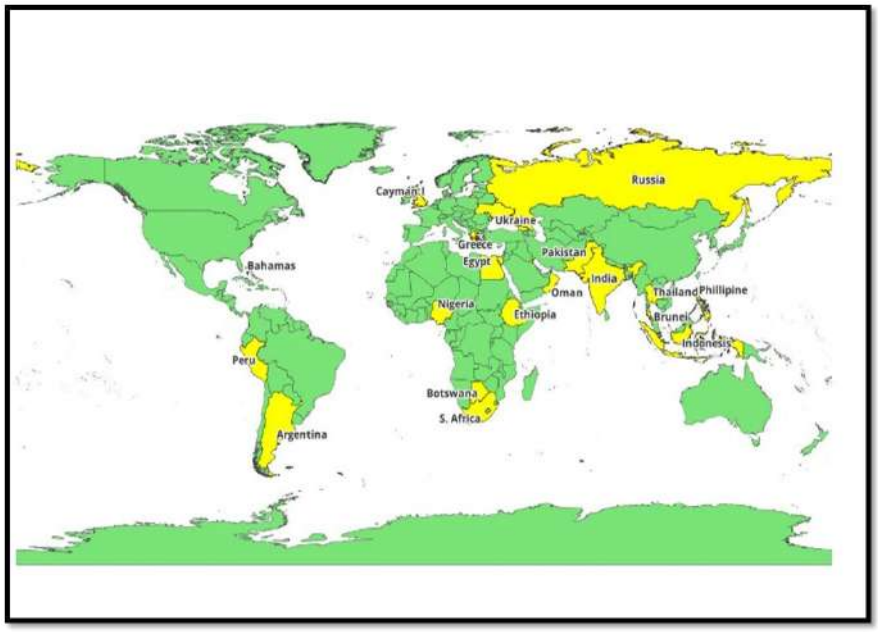
International Webinar on "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14" (25th and 26th September 2023)



Participants during International Webinar on "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14", (Batch-I and II), 25th and 26th September 2023

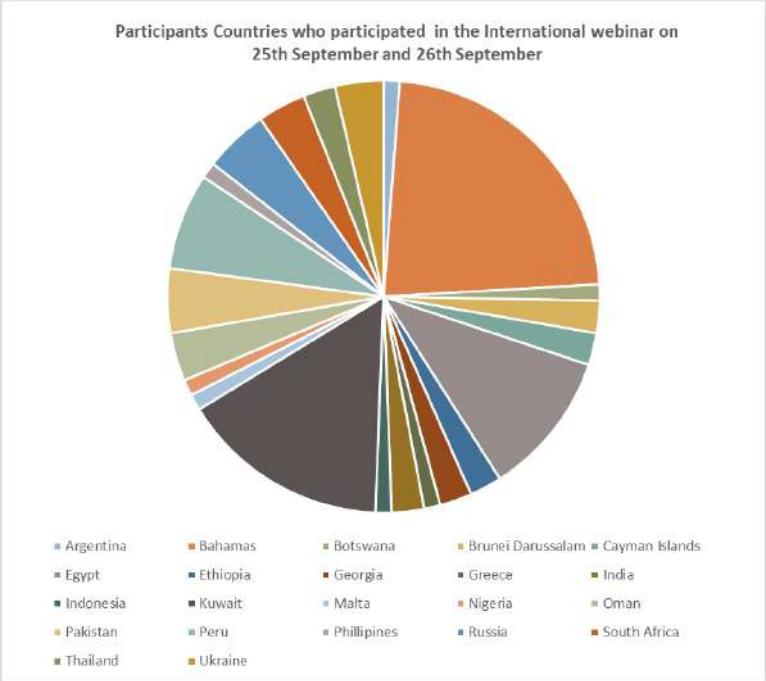
iCED in the capacity of Global Training Facility (GTF) of INTOSAI Working Group on Environmental Auditing (WGEA) organised another International Webinar on "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14" on 25 September 2023 (Batch-I) and 26 September 2023 (Batch-II). A total number of 82 participants from 22 SAIs participated in this training programme through virtual mode.

Participants during International Webinar on "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14", 25th & 26th September 2023



Map representing 22 SAI's participants in yellow colour, in the International Webinar, 25th and 26th September 2023

While inaugurating (both the batches), ADAI, iCED stated that the Sustainable Blue Economy offers solution to numerous challenges posed by Climate Change and resource extraction, by promoting development of ocean resources in a fair and equitable manner.



Participant Nations in the International Webinar on 25th and 26th September 2023

Faculties delivering sessions during International Webinar on "Audit of Blue Economy, Issues and Challenges with special reference to SDG-14"

During this webinar, resource persons from the National Institute of Ocean Technology (NIOT), Chennai, The Energy and Resources Institute(TERI), National Audit Office, Mauritius, The Audit Board of the Republic of Indonesia, The Court of Auditors of The Kingdom of Morocco, European Court of Auditors (ECA), The Federal Court of Accounts of Brazil (TCU) and other experts from SAI India shared their experiences related to Audit of Blue Economy, Issues and Challenges with special reference to SDG-14.

Valediction of the International Webinar

Ms. Sayantani Jafa, ADAI and DG, iCED addressing the participants at the International Webinar (Batch I and II), 25th and 26th September 2023

ADAI and DG, iCED graced the valedictory session. She conveyed her compliments to the participants for their active involvement and credited all who were involved in the success of this programme. The average feedback received from participants on September 25th and 26th, 2023, for the webinar was 9.2 and 8.8 out of 10, respectively, which was very encouraging for iCED, in view of the dynamic and evolving nature of the theme.

We are greatly encouraged by the positive feedback on the sessions:

"The Seminar was awesome and the learning experience and material to be used in adding value to SAI Bahamas in the delivery of quality level audits".

Brenda Neeley, Deputy Auditor General from SAI Bahamas

"When I supported the coordinated audit of protected areas in 2014 and 2021, SGD 14 and 15 were reinforced as explained in the TCU presentation. However, what I received in this webinar, reinforces the work in performance auditing related to Sustainable Development".

Jéssica Rodríguez Guillén, Contraloria General de Perú/Perú, SAI Peru

"The existence of Global and National Indicator Frameworks is of great help in gauging and identifying focused audit areas".

Janno Louie Ceasar Luzon, SAI Philippines

"The seminar gave different and unique insights on how to approach the concept and audit of blue economy".

Ms. Saranya Baskar, SAI India,

National Workshop on "Climate Change with reference to Marine Ecosystem, Biodiversity Loss and Marine Pollution"

Group Photo during National Training Programme on "Blue Economy: Blue Economy with special focus on Marine Tourism and Audit of SDG-14 and related SDGs (Terrestrial & Aquatic)"

A National Workshop on the above topic was organised from 03rd to 04th July, 2023. A total of 30 participants from 10 field offices participated in this workshop. During the inaugural session of the Workshop, Shri Ramawatar Sharma, Principal Director (In-charge), iCED emphasised that Climate Change poses a significant threat to the marine environment, resulting in rising sea levels, ocean acidification, increased temperatures and extreme weather events. He also provided an overview of the workshop's agenda, discussing various issues to be covered and underscored the crucial role of auditing in addressing Climate Change concerns.

NTP on "Blue Economy: Blue Economy with special focus on Marine Tourism and Audit of SDG-14 and related SDGs (Terrestrial & Aquatic)"

A National Training Programme (NTP) on the above topic was organised from 21st to 25th August, 2023 at iCED. A total number of 20 participants from seven field offices attended the training programme.

While inaugurating, ADAI and DG, iCED welcomed all the participants and emphasised the importance of the training programme, from the perspectives of audit of Blue Economy.

During this programme, nine experts from various organisations such as The Energy and Resources Institute (TERI), Annamalai University, Tamil Nadu, National Maritime Foundation (NMF), National Centre for Coastal Research (NCCR), Director General of Shipping, Indian National Centre for Ocean Information Services (INCOIS) and IA&AS Officers from Indian Audit and Accounts Department (IA&AD) were invited to deliver the sessions on various aspects of Marine Tourism and Audit of SDG-14 and related SDGs.

Summing-up and valediction: During valedictory address, ADAI and DG, iCED highlighted the announcement by the Hon'ble Comptroller and Auditor General of India, Shri Girish Chandra Murmu, about the establishment of a Centre for Excellence on Audit of Blue Economy at iCED. She extended her compliments to all the experts and participants for their valuable contributions, attributing to the success of the event. Additionally, she expressed a desire to organise more sessions in the near future to facilitate a broader understanding of the topic.

National Training Programme for IA&AS Officer Trainees (2022 Batch) on "Environment Audit"

Group Photo during National Training Programme for IA&AS Officer Trainees (2022 Batch) on "Environment Audit"

iCED organised a NTP on "Environment Audit" from 31st July to 05th August 2023 for the Indian Audit and Accounts Service Officer Trainees of the 2022 Batch. Overall 18 officer trainees, including two officers from Bhutan and two from Maldives, participated in the training programme.

During the inauguration, ADAI and DG, iCED extended a warm welcome to all the participants and highlighted that the primary objective of the NTP is to offer participants a comprehensive understanding of various facets of Environmental Audit, encompassing their challenges, opportunities and the essential policies and strategies necessary to foster the sustainable development.

Summing-up and valediction: ADAI and DG, iCED graced the valedictory session and requested all the officer trainees to actively contribute to iCED's quarterly newsletter 'Green Files' as by doing so, they would help to disseminate valuable information and perspectives to a broader audience, fostering a culture of continuous learning and knowledge exchange.

National Training Programme on "Blue Economy: A Multi-Dimensional Overview with special focus on Marine and Coastal Ecosystem Conservation Measures"

A 10 days' NTP on said topic was organised by iCED from 17th to 27th July, 2023. A total of 20 participants from seven field offices participated in the training programme.

Group Photo during National Training Programme on "Blue Economy: A Multi-Dimensional Overview with special focus on Marine and Coastal Ecosystem Conservation Measures

Inaugurating the training programme, ADAI and DG, iCED welcomed the participants and outlined that primary focus of this programme is to equip participants with an in-depth understanding of the different sectors of the Blue Economy, their challenges, opportunities, and the policy paradigm and required strategies to ensure sustainable growth of sectors of the Blue Economy. During this programme, experts from IA&AD, Research Associates from iCED and many other reputed organizations such as TERI, National Centre for Coastal Research (NCCR), National Maritime Foundation (NMF), and the World Bank etc. provided faculty assistance to deliver the sessions.

Summing-up and valediction: During valedictory address, ADAI and DG, iCED highlighted that the Blue Economy is a labyrinthine and multifaceted area which is driving economic growth and innovation. Its vital importance is thus opening up new frontiers for auditing. She thanked all the experts and participants for their contributions in making this event a success and desired to organise more sessions in the near future to understand the topic more broadly.

National Training Programme on "Audit of Climate Change with special reference to Green Finance and Energy Security"

iCED organised a five days' National Training Programme on "Audit of Climate Change with special reference to Green Finance and Energy Security" from 11th to 15th September 2023. A total of 19 participants from seven field offices including six group officers, participated in the training programme.

Dr. Nanda Dulal Das, Director (Training and Research), iCED welcomed all the participants on behalf of the Addl. Deputy Comptroller and Auditor General and Director General, iCED and outlined the importance of the programme. Further, Shri Mehul Grover, Director (Administration) briefed the participants about iCED's stay facilities, infrastructure and wished for their fruitful and comfortable stay. During this programme, nine experts from IA&AD and many other reputed organisations such as The Energy and Resources Institute (TERI), The World Resources Institute (WRI) India, World Bank etc. were invited to deliver the sessions.

Summing-up and valediction: Shri Mehul Grover, Director (Administration) and Dr. Nanda Dulal Das, Director (Training and Research), iCED graced the valedictory session and encouraged all the participants to apply the knowledge and skills acquired in the programme in their upcoming audits.

Bibliography

C&AG of India. "CAG bags highest Hindi award Rajbhasha Kirti Puraskar." Presss Release CAG of India. September15,2023.https://cag.gov.in/uploads/PressRelease/PR-CAG-bags-highest-Hindi-award-Rajbhasha-Kirti-Puraskar-065043de822f209-68527976.pdf (accessed October 30, 2023).

—. "CAG Press Release." CAG of India Press Release. September22,2023.https://cag.gov.in/uploads/cag_speeches/speeches-0650d78cfa5cc67-47050328.pdf (accessed October 30, 2023).

CNAO China. "9th ASOSAI Seminar on Environmental Auditing and the 9th Working Meeting of ASOSAI WGEA Held in Kazakhstan." CNAO China. September 13, 2023. http://yashen.icnao.cn/news/202309/t20230912_259789.html (accessed October 30, 2023).

By: Manoj Kumar, AAO

New Literature Review on Climate and Biodiversity Nexus Out

The International Organisation of Supreme Audit Institutions (INTOSAI) Working Group on Environmental Auditing (WGEA) has published a literature review on Climate – Biodiversity nexus: Relationship of Climate Change Mitigation and Biodiversity policy measures that was commissioned by the National Audit Office of Finland from the Finnish Environment Institute. The review studies the interrelationship from the perspective of four ecosystems: boreal forests, coral reefs, deserts/semi-deserts and arid/semi-arid grasslands, and freshwater ecosystems.

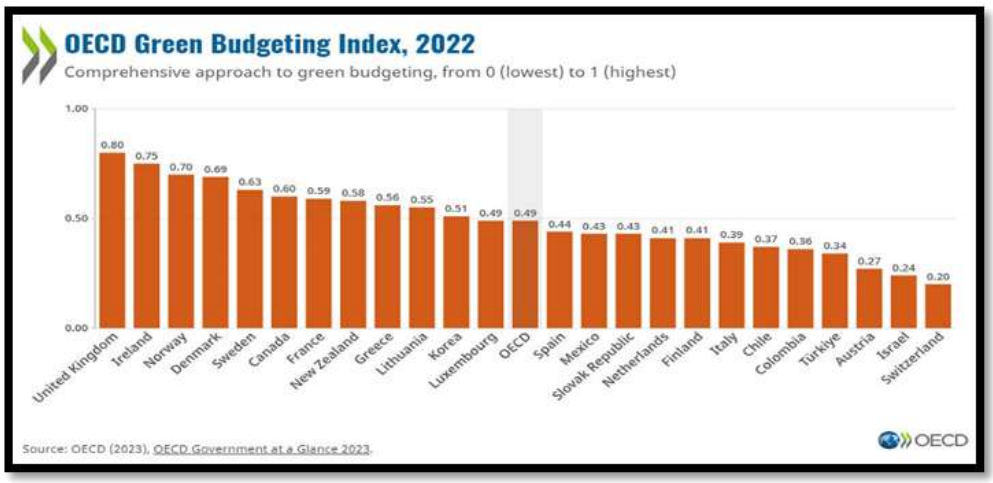


Figure 1: OECD Green Budgeting Index, 2022

The literature review affirms the presupposition that Climate Change mitigation measures may carry adverse biodiversity impacts. The development of renewable energy (such as solar, wind, hydro and tidal/wave power) seems to affect all of the selected ecosystem types. Whilst renewable energy development is central for the transition away from fossil-based energy, these measures may also come with adverse biodiversity impacts. However, ecosystem-based mitigation measures were found to benefit both climate and biodiversity targets (INTOSAI WGEA, 2023). The literature review can be accessed at https://wgea.org/media/mkoj2l4k/nexus-literature-review-final-2023.pdf.

Bibliography and Reference

INTOSAI WGEA. "New Literature Review on Climate and Biodiversity Nexus Out." November 7, 2023. https://www.environmental-auditing.org/news-events/new-literature-review-on-climate-and-biodiversity-nexus-out/ (accessed November 29, 2023).

Book Review: Marine Pollution and Human Health
R.E. Hester and R. M. Harrison (Ed.). (2011)

Reviewed by: Dr. Nanda Dulal Das
Director (Training and Research)

The Book "Marine Pollution and Human Health", edited by R. E. Hester and R. M. Harrison, with contributions from sixteen prominent authors, provides significant and valuable understanding of the interaction between marine environment and human health, from the perspectives of natural land-based, oceanic, and anthropogenic processes. The first chapter on overview suggests a conceptual framework emphasising on ecosystem-based management of marine resources. This approach, as reflected through the European Union (EU) Marine Strategy Framework Directive, calls for an overall assessment of impact of human activities on marine environment and development of integrated management measures. Through use of Driver-Pressure-State-Impacts-Response (DPSIR) framework, where socio-economic and cultural forces (Drivers) and anthropogenic stressors (Pressures) effect the marine environment (State), which in turn impact human health (Impact), resulting in institutional response to the changes in the marine environment (Response), the Author, J. Icarus Allen, has attracted attention of policy-makers and researchers to explore both positive and negative impacts of human activities on the marine environment and vice versa.

While the first chapter sets the introductory tone of the book well, the following chapters provide a detailed analysis of origin, measurement, impacts on the microbial pathogens, pollutants and algal blooms in the marine environment on the human health and well-being, while the last chapter provides a vivid account of the scientific challenges and policy needs for addressing public health issues and needs for remediation and improvement of the marine environment.

Pathogens and the associated challenges: While many viruses, bacteria, fungi, amoeba and eukaryotic cells are present in the seawater, all of them are not harmful or pathogens. The book mentions that more than 50 pathogens, which poses potential threat to human health and causes diseases like cholera, pneumonia, Gastrointestinal (GI) illness, wound infections, sepsis, and skin, ear and respiratory infections, have been identified. While many pathogens are 'indigenous' and are part of the natural aquatic microbial community, generated through natural processes, most of the disease-causing pathogens are released by anthropogenic activities, birds, animals, finding their way to marine water through point and non-point run-off sources. Stewart et. al. in the second chapter have also provided several methodologies for detection of pathogens in water, challenges therein and shown correlation between pathogens and diseases caused due to recreational use of water (like swimming, water sports etc.) through microbial indicators like fecal coliforms, Escherichia coli, Enterococci, bacillus spores, Clostridium perfringens etc. The chapter also mentions about scope for using Remote Sensing in detection of presence or spread of waterborne diseases, depending on data on sea surface temperature, height, salinity, turbidity, chlorophyll, ocean colour, distribution of wetlands and degree of flooding.

Effects of Chemical Pollutants on Human Health: Unlike the pathogens, the effects of chemical pollutants on human health are usually more subtle and chronic than acute. Chemicals and pollutants are considered to be of potential concern, based on their classification under Persistence, Bioaccumulation and Toxicity (PBT) criteria. Seafood contaminated with chemicals enter the human body through the food-chain and such biological magnification is becoming more prominent with increasing aquacultural activities.

For protection of human health from Persistent Organic Pollutants (POPs), the Stockholm Convention, effective from 2004, required parties (countries) to take measures to either eliminate or restrict production and use of chemicals like Aldrin, Chlordane, and Dichlorodiphenyltrichloroethane (DDT) etc. Besides, there are many emerging pollutants, nanoparticles and plastics, which find their way to ocean-water, but are not currently monitored or controlled by regulations. Monitoring these pollutants and bringing in regulations would be required to effectively control the contamination of ocean water from anthropogenic sources. Climate Change can exacerbate release of chemicals and pollutants in the oceanwater ocean-water, impacting human health further.

Furthermore, harmful phytoplankton and 'Harmful Algal Bloom' (HAB), which releases bio toxins in the ocean-water have deadly impact on fishes and human use of marine ecosystems. These pollutants enter human bodies mainly through skin contact and ingestion. With increasing consumption of fish and shellfish globally, several types of shellfish poisoning are increasingly reported in human beings. Average annual cost of HABs on the commercial fisheries, public health and recreation/tourism in the United States (US) Economy was estimated to be US $550 million between 1987 and 1992 (P. Hoagland, D. M. Anderson, Y. Kaoru and A.W. White, 2002). Climate Change also impacts such HABs in complex ways through impact on different species and locations. Role of satellite imageries, field observations, mathematical models, public health reports and data from instruments are used to anticipate such HABs and take precautionary measures.

Holistic Systems Approach: In the last chapter, the authors, M.N. Moore, R. Owen and M. H. Depledge have suggested a holistic systems approach, like an Integrated Coastal Zone Management approach, combining natural and social systems, based on information from five operational modules, such as ecosystem productivity; fish and fisheries; pollution and health; socio-economic conditions and governance protocols.

There are need for identification of appropriate diagnostic and prognostic markers of health, which have been encountered during analysis in the chapters on pathogens, chemical pollutants and HABs. Besides, how such markers can be related to human health, needs to be investigated. Development of a Systems approach through consideration of controlling processes, integration of data, modelling and assessment methodology for a generic understanding of marine pollution on human health and developing a system for forecasting would be helpful in developing a complex yet integrated science. Precautionary principles, integrated risk assessment and management approaches have dominated the policy scape in the developed countries, as reflected through the national Laws in Europe and European Union (EU) Water Framework Directive (2000/60/EC). While the book has done an extensive analysis of pathogens, pollutants and HABs in marine waters, drawing examples from Europe and America, lack of examples from developing countries are starkly reflected in the book. Besides, while discussing the policy needs, the book has heavily relied on the policies of the developed world, assuming that such approaches would equally be successful in coastal areas of developing nations, which grapple with heavy pressure of population and lack of resources to keep the marine environment clean.

Bibliography

R.E. Hester and R. M. Harrison (Ed.). (2011). Marine Pollution and Human Health (Vol. 33). Cambridge, UK: The Royal Society of Chemistry (RSC Publishing).

P. Hoagland, D. M. Anderson, Y. Kaoru and A.W. White. (2002). Estuaries. 25, 819.

Book Review: Renewable Energy and Energy Conservation Edited by Dr. V. Kirubakaran and Dr. R. Seerangarajan (2012), Published By Aph Publishing Corporation, New Delhi

By: Kamal Kumar Sahal, Consultant

Introduction

The book "Renewable Energy and Energy Conservation" is a comprehensive exploration of renewable energy sources and energy conservation strategies, particularly in India. It features multiple chapters by experts, each focusing on different aspects of renewable energy and its applications.

Key themes discussed under the book are as follows:

1. Solar and Wind Energy

Non-conventional energy sources like solar, wind, and hydro-thermal systems promote energy efficiency, social responsibility, and job creation, while also being cost-effective and reducing carbon footprint. Solar energy has a potential of 178 billion megawatts (MW), meeting 20,000 times the world's demand. It can be used thermally or through photovoltaic cells, with thermal being used for water production in rural areas. Currently, solar energy accounts for 10 per cent of global energy use, but 40 per cent in developing countries. Wind energy, primarily its mechanical motion, is used for pumping fluids and power generation.

2. Use of Biomass and Biodegradable Waste

India's heavy dependence on coal for electricity generation raises environmental issues like acid rain and ozone depletion. The government's plans to increase coal-based power generation capacity raise air pollution concerns. Biomass fuels are explored as an environmentally friendly alternative due to their low Carbon dioxide (CO_2) emissions. Co-firing biomass in coal-fired plants are explored as a solution towards reduction in Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x), CO_2 emissions, as compared to the conventional coal-powered plant.

Rural India faces power shortages due to its reliance on centralised grid supply. Biomass, including crop residues, agricultural waste, and wood, is a promising renewable energy source. Biomass gasifiers convert solid fuel into gaseous fuel, reducing wood consumption by 50 per cent, offering environmental benefits, and providing energy security.

Although India's economic growth is on an upward trajectory, it imports over 30 per cent of its commercial energy. Bagasse and sugar-cane residues have a high potential for exportable electricity production, with a calorific value of 1.8 GCal/T and 80 per cent boiler efficiency. India can generate over 4000 MW of electricity using bagasse, reducing environmental depletion from conventional energy.

Biodegradable waste generation and disposal in India pose environmental and health issues. Biomethanation is a promising treatment option for solid wastes, producing bio-gas that can replace conventional fuels and provide organic manure. The fourth chapter of book explores the benefits and drawbacks of treating biodegradable waste in tanneries to generate energy-rich methane gas, which can be tapped and used for fuel a power generator. This also reduces the potential release of methane gas into the atmosphere.

3. Biofuels in India

India is exploring Jatropha curcas as a bio-diesel crop to boost rural economies. The plantation can reduce emissions, improve soil fertility, and create employment. However, challenges like seed procurement and limited land availability persist. Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis suggests developing intercropping techniques, increasing ethanol production, providing incentives, promoting Jatropha cultivation, and promoting energy-based education could be some of the solutions.

4. Key issues in Rural Electrification

The sixth chapter of the book discusses India's commitment to renewable energy since the 1970s, highlighting the country's significant efforts in developing and deploying renewable energy products and systems. It highlights the country's large potential for renewable energy, estimated at over 100,000 MW, but only a fraction of which has been utilised, particularly in solar energy. The chapter also highlights the challenges in rural electrification, such as lack of electricity, insufficient power supply, and the impact of blackouts and brownouts. It emphasises the need for close cooperation between the corporate sector, government, and Non-Governmental Organisations (NGOs) for successful rural electrification missions.

5. Steps to improve energy utilisation

With approximately 0.3 per cent of the world's known oil reserves, India faces an energy crisis due to a scarcity of non-renewable resources. The trade imbalance is unfavourable as a result of substantial imports of petroleum products, which result in higher import costs. India has a tremendous potential for producing biogas, biofuel, solar energy, and wind energy, but problems include a lack of desire, inadequate training, high expenses, competitive pricing, and the replacement of Gobar gas cylinders with Liquefied Petroleum Gas (LPG) cylinders. The study's goals are to explain India's energy issue, assess the applicability of Gobar gas units for rural development, explain bio-gas generation, evaluate the economic feasibility of Gobar gas plants, and offer recommendations for maximising rural energy resources. Solutions include producing biogas from cow dung, using solar energy, producing biofuel from Jatropha, and changing government policy.

6. Security Challenges and Policy

The Electricity Act, 2003 in India mandates state regulatory commissions to promote renewable energy generation. The National Electricity Policy aims to make electricity accessible to all households, including rural areas, within five years. The Renewable Energy sector in India includes small-scale and medium-scale units, with large-scale industries manufacturing solar cells and wind turbines.

The Ministry of Non-conventional Energy Sources (MNES), and Indian Renewable Energy Development Agency (IREDA) promote renewable energy investments, while Rural Electrification Corporation (REC) finances schemes and cooperatives, utilising government and other funding sources. Opportunities include electrification of un-electrified households, achieving 6.5 per cent Gross Domestic Product (GDP) growth, and easy financing for private companies. Demand management is crucial, along with measures to curb wastage and promote energy efficiency. Policy outlines include assessing long-term goals, integrating ministries and departments, promoting joint research and development by industry and academia, and addressing environmental concerns.

The book "Renewable Energy and Energy Conservation," edited by Dr. V. Kirubakaran and Dr R. Seerangarajan, is expected to be well received by its target audience, which includes policymakers, researchers, business professionals, and individuals with a strong interest in renewable energy.

In summary, "Renewable Energy and Energy Conservation" is an important resource for a specialised readership interested in renewable energy and energy conservation, particularly in the Indian setting. It offers detailed knowledge and practical answers to people working in or studying the area. However, ordinary or non-technical readers who are not actively involved in the energy or environmental sectors may find it non-engaging.

Conclusion

The chapters in the book provide a thorough review of various renewable energy sources and their uses in India. The book emphasises the importance of solar, wind, and biomass energy in promoting energy efficiency, environmental sustainability, and economic growth. Each energy source's prospects and constraints have been examined, with an emphasis on the potential for creation of employment, reduced carbon impact, and improved rural electrification. The book emphasises the necessity of strategic policy measures, collaboration between the government, business sector, and NGOs, and public awareness and education in addressing energy concerns and promoting sustainable development in India.

Blue Economy and Sustainable Development Goals: A Review Article

By: Dr. Mohd. Suhail Fazal, IA&AS

Blue Economy focuses on the responsible utilisation of the planet's ocean resources to nurture sustainable economic growth while safeguarding the health and resilience of our marine ecosystems. The concept of Blue Economy originated from the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012 (UNCTAD, The Oceans Economy: Opportunities and Challenges for Small Island Developing States, 2014). In the context of the Blue Economy, the United Nations' Sustainable Development Goals (SDGs) imply that economic development is both inclusive and environmentally sound, and highlight the need to balance the economic, social, and environmental dimensions of sustainable development in relation to oceans (David Griggs 2013). The United Nations (UN) has declared 2021 to 2030 as the 'Decade of Ocean Science for Sustainable Development' to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework. The Food and Agriculture Organisation estimates that Blue Economy industries assure the livelihoods of 660 to 820 million people worldwide.

The SDGs and related 17 goals (as depicted in Figure 1) , 169 targets and 232 indicators result from a multi-stakeholder agreement between countries, designed to reduce unsustainability and promote sustainable development globally (United Nations 2018). However, the identification of the scope and boundaries of the Blue Economy in line with the UN's SDGs is vague and even challenging. In a bid to identify SDG linkages to Blue Economy, we can quote a literature review study (Ki-Hoon Lee, 2020) wherein 26 papers from 18 journals were analysed and summarised below:

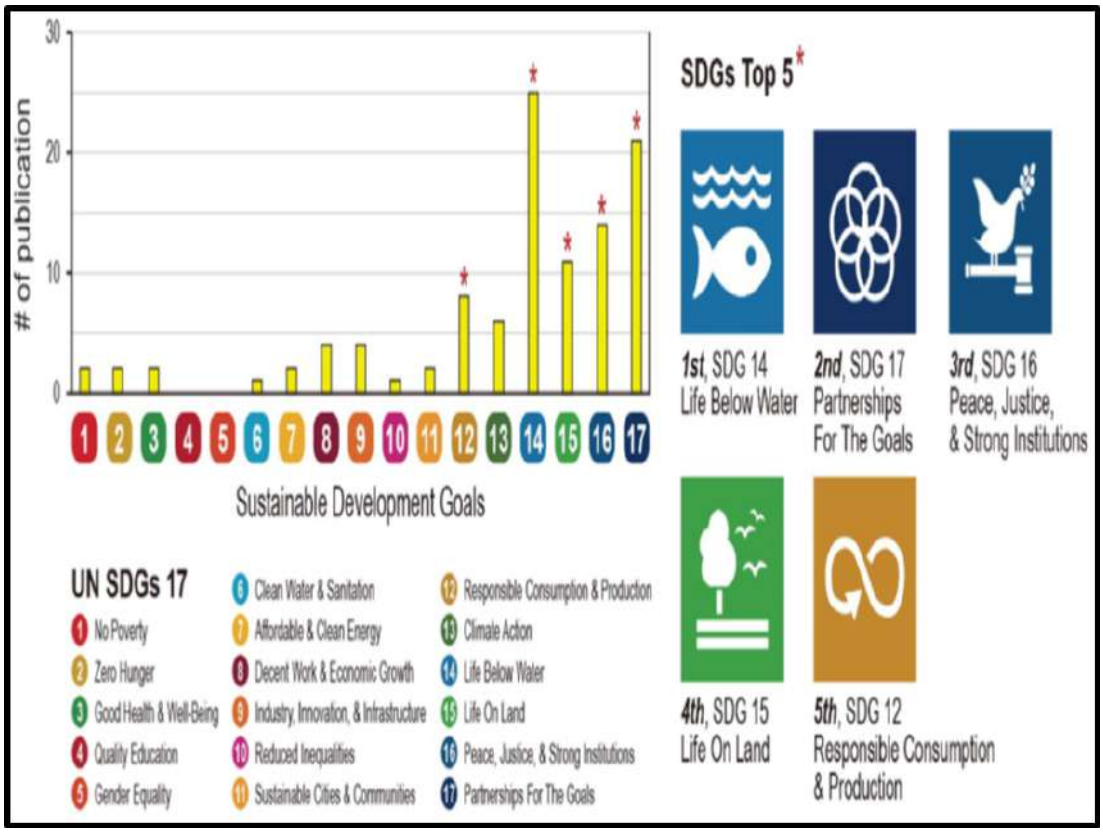


Figure 1: Interconnected Progress: The top 5 Sustainable Development Goals (Source: (United Nations 2018))

It is evident that Blue Economy is more prominently linked to SDG12-17, while touching somehow to most of the SDGs. SDG 14 Life below Water, SDG 17 Partnership for the Goal are highly linked to achievements under SDG, while some like SDG 6 Clean water and sanitation is not highly linked in current scenario. Blue Economy has multi-dimensional correlation (weak or strong) to SDGs across sectors which need to be further developed in future.

Conclusion

Above scenario shows top five SDG linkages with Blue Economy, but how rest of other SDGs are linked to Blue Economy, needs to be further explored by researchers and by involvement of stakeholders (Non-Governmental Organisations (NGOs), policy makers, Industries, local communities and local governments etc.). How Blue Economy is envisioned and interpreted by different stakeholders in near future will lead to strengthening and fulfilment of SDGs.

Bibliography

David Griggs, Mark Stafford-Smith, Owen Gaffney, Johan Rockström, Marcus C. Öhman, Priya Shyamsundar, Will Steffen, Gisbert Glaser, Norichika Kanie & Ian Noble. 2013. Sustainable development goals for people and planet. 20 March. https://www.nature.com/articles/495305a.

Ki-Hoon Lee, Junsung Noh, Jong Seong Khim. 2020. The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. Accessed December 9, 2023. https://www.sciencedirect.com/science/article/pii/S0160412019338255?via%3Dihub

UNCTAD. 2014. The Oceans Economy: Opportunities and Challenges for Small Island Developing States. https://unctad.org/system/files/official document/ditcted2014d5_en.pdf.

United Nations. 2018. UN Department of Economic and Social Affairs. https://sdgs.un.org/goals.

Towards a Sustainable Blue Economy: Incorporating Green Norms in Ships' Underwater Hull Protection Practices in India (Reprinted with kind permission from the National Maritime Foundation)

Article previously published on April 13, 2023

By: Ayushi Srivastava and Commodore Debesh Lahiri

Abstract

The synthesis report of the Inter-governmental Panel on Climate Change (sixth assessment report) has unambiguously stated that the earth's climate is changing at an alarming rate, with global surface temperature reaching 1.1°C above 1850-1900 levels, during the period 2011-2020, principally through anthropogenic greenhouse gas (GHG) emissions that have unequivocally caused global warming.[1] The International Maritime Organisation (IMO) has embarked on a 'mission mode' to reduce annual greenhouse gas emissions from international shipping by at least half, by 2050, compared to the 2008 emission levels (which are taken as the baseline) and reducing carbon intensity (carbon dioxide emissions per unit transport work) by at least 40 per cent by 2030, while continuing to pursue efforts towards a reduction of 70 per cent by 2050[2].

It is appreciated by the authors that meeting these goals, would require a mix of technical, operational and innovative solutions. This paper examines one such solution which is specifically applicable to ships, viz., an underwater-hull protection system (a'k.a. hull biofouling management) that has the potential to reduce GHG gases by approximately 5 to 25 per cent. [3] This paper examines the ship's underwater hull protection techniques used in India and latest trends available globally, and makes specific implementable recommendations for the Indian shipbuilding and ship repair sector towards becoming more environmentally sustainable. Since, this research article is an outcome of Corporate Social Responsibility (CSR) funds, a deliberate attempt has been made by the authors to educate the lay public about the basics of biofouling on a ship's hull and its prevention.

Keywords: Biofouling, Anti-fouling paints, Sustainability, Green technology, Maritime, Underwater Hull Protection Practices, Air lubrication systems, AIRCOAT, Silverstream technology, Indian Shipbuilding and Repair Industry

Biofouling and its Repercussions:

Biofouling is described as the undesirable accumulation of microorganisms, plants, algae, and animals on the submerged part of a vessel (especially a ship's hull). It is also considered to be one of the main vectors for bio-invasions (transfer of invasive aquatic species from one geographical location to another).[4] Biofouling on the hulls of ships enhances the roughness of the colonized surface, which results in an increase of hydrodynamic drag, which consequently leads to higher fuel consumption, and concomitantly, higher GHG emissions, for the same distance traversed or speed attained. Thus, effective management of biofouling of the underwater hull can generate significant gains in terms of reduced fuel consumption and decreased GHG emissions.

The IMO has partnered with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) under the project named "GloFouling Partnership Project" to protect marine ecosystems from the negative effects of invasive species. The objective of the project is to build capacities in developing countries for implementing IMO Biofouling Guidelines and other relevant recommendations for the management of biofouling and to catalyse the overall reduction of GHG emitted by global shipping.[5] The project analysed the impact of marine biofouling on the energy efficiency of ships and released a report that highlighted the fact that a biofouling layer of slime as thin as 0.5 mm, covering up to 50 per cent of an underwater hull surface, could trigger an increase of GHG emissions in the range of 25 to 30 per cent, depending on the characteristics of the vessel, its speed and other prevailing conditions.[6] There are a number of non-traditional methods such as ultrasonics, electric currents, magnetic fields and optical methods, which are available to control biofouling. However, amongst all traditional and non-traditional methods available, perhaps the most cost-effective method is the use of anti-fouling coatings (paints) and, in particular, biocidal anti-fouling paints.

Anti-fouling Coatings and Aquatic Invasive Species:

Anti-fouling coatings are specialised underwater paints that are applied to the underwater area of the hull, to slow the growth of sub-aquatic organisms which would otherwise adversely affect the performance of the vessel while underway, while also reducing the time period between successive dry-dockings for scheduled maintenance. However, 'anti-fouling' chemicals (also known as 'biocides') are, for the most part, toxic materials and have a deleterious effect upon the marine environment.[7] The IMO's Anti-Fouling Systems (AFS) Convention, which prohibits the use of harmful 'organotin' in anti-fouling paints to prevent the potential

future use of other harmful substances in anti-fouling systems, has been accepted.[8] While this convention banned the use of 'tributyltin' (TBT) in 2008, several marine scientists and ecologists believe that the current replacement for TBT is only slightly less harmful and is still adversely affecting the marine eco-system.[9] Further, the spread of invasive species has long been recognised as a significant marine environmental threat — one that impacts tourism, aquaculture, fisheries, and results in costly damage to marine infrastructure.[10] It is this realisation that led the Marine Environment Protection Committee (MEPC) of the IMO to promulgate Guideline 207(62) for the control and management of biofouling of ships, thereby minimizing the transfer of invasive aquatic species from one geographical location to another.[11] Invasive Aquatic Species (IAS) may be defined as species that may pose threats to human, animal, and plant life, economic and cultural activities, and the aquatic environment.[12] Thus, it can be appreciated that the impact of biofouling is not limited to the performance of the vessel alone but also adversely impacts the marine eco-systems, directly or indirectly.

Historically, the shipbuilding and the ship-repair industry has underestimated the adverse effect of biofouling.[13] Presently, the use of anti-fouling paints remains the option of choice for preventing biofouling growth. Therefore, there is tremendous potential for research-and-development agencies to develop underwater-hull protection techniques to provide viable alternatives to anti-fouling paint coatings. In 2021, the MEPC adopted an amendment to include controls on the biocide 'cybutryne'. The amendment included a stipulation that with effect from 01 January 2023, ships shall not apply or re-apply anti-fouling systems containing this substance. The amendment also stipulated that ships shall remove any coating of AFS containing this substance at the next scheduled renewal of the anti-fouling system after 01 January 2023, but

no later than 60 months following the last application to the ship of an anti-fouling system containing cybutryne.[14] This circular has brought other non-traditional methods of underwater hull protection techniques into the limelight for use by the shipbuilding and ship-repair industries.

Biofouling Prevention Methods Used in Indian Shipbuilding and Ship Repair Industry:

Ship painting and underwater-hull protection are important for improving the propulsive efficiency of a ship as these measures reduce the roughness of a ship's hull, while protecting and preserving the thickness of the underwater hull plates from corrosion, etc. The increase in hull roughness increases ship's drag and hull friction, both of which directly reduce the ship's speed while increasing the fuel consumption of the main engines. There are two major factors affecting hull roughness — physical and biological. Physical factors include poorly ground weld seams, welding defects, hull plate waviness, plate lapse and corrosion/mechanical damage etc., whereas the biological factors include weed fouling, animal fouling, algae, barnacles, slime, etc. Improper maintenance or malfunctioning of Impressed Current Cathodic Protection (ICCP) systems can also result in an increase of hull roughness.[15]

The Indian shipbuilding industry has 28 shipyards, of which six are under the Central Public Sector, two under State Governments, and the remaining 20 are Private Sector Undertakings.[16] According to the Ministry of Ports, Shipping and Waterways (MoPSW) report of 2021-2022,[17] there are 38 dry-docks in India for ship construction and repair, incorporating both, the public and private sector. In 2021-22, amongst public sector companies, Cochin Shipyard Ltd (CSL), Kochi, had the highest capacity for ship repairs (1,25,000 DWT) followed by Hindustan Shipyard Ltd. (HSL), Visakhapatnam, at 80,000 DWT, and Goa Shipyard Ltd. (GSL), Goa, (4,500 DWT). In the private sector, Waterways Shipyard Pvt. Ltd. (WSPL), Goa, (8,000 DWT) had the highest capacity for ship repair, followed by Modest Infrastructure Pvt. Ltd. (MIPL), Gujarat, (6,000 DWT) and Mandovi Drydocks (MDD), Goa, (5,000 DWT).[18]

As the Indian shipbuilding industry is moving towards modernisation, hull coating as one of the essential elements of shipbuilding and ship repair process needs to be analysed for accelerating the transition.[19] An analysis, which focused on the underwater hull protection techniques used in major shipyards of India, was conducted by National Maritime Foundation (NMF). A questionnaire, designed to understand the current scenario in the shipyards and their future plans with respect to underwater hull protection techniques, was circulated to some public and private sector shipyards, and their responses collated. The questionnaire comprised ten questions covering the entire gamut of underwater hull protection techniques with special emphasis on new trends incorporating green technologies. A three-point Likert Survey Scale was developed using the responses received from the different shipyards. (A Likert scale is a psychometric and unidimensional scale used to assess and understand participant's opinions on a series of statements.[20]).The Likert Scale below highlights the opinion of shipyards on four questions related to underwater hull protection techniques. The scale distributes the responses into three anchor points: 'agree', 'disagree', and 'neutral'. There is also a conditional dependence of the answers with respect to the requirement of the shipowners for ship construction or repair. Thus, the neutral point indicates the dependence of building of vessel on the owner's requirement, which may or may not include the sustainable practices over the commonly used commercial methods.

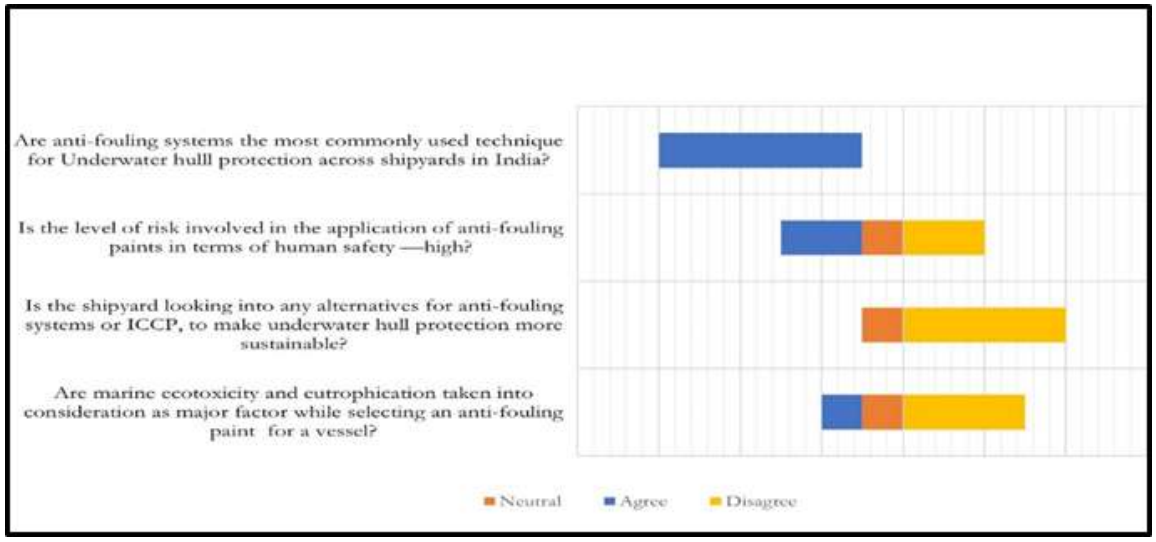


Table 1: Likert Scale generated from the Indian Shipyards' responses
Source: Data collated from Shipyards and analysed by the Authors

The Likert Scale derived from the responses only reinforced the anticipated outcomes for the questions asked. The results showed that the most commonly used technique for underwater hull protection in India remains the application of anti-fouling paint, and that marine ecotoxicity and eutrophication are yet to become decision-making factors in the selection/non-selection of anti-fouling paints for the underwater hull of a vessel. In terms of sustainability, the hull coating practices are driven by the shipowner's requirement, and is a long way from becoming a norm in the commercial ship building and repair industry. A query relating to the level of risk involved in application of anti-fouling coatings evoked a mixed response, as some shipyards considered it highly risky for the human workers involved, while other shipyards considered this to be much less risky.

The incorporation of sustainable underwater hull protection techniques in shipyards is a viable pathway towards decarbonisation of the shipping sector, as sustainable underwater hull practices are amongst the short-term measures that can be adopted by shipyards for reducing the hydrodynamic drag and thereby reducing GHG emissions from vessels. In January 2022, the Ministry of Ports, Shipping and Waterways (MoPSW), Government of India (GoI) had announced an initiative for 'green' ports and 'green' shipping as part of the Maritime India Vision 2030, so as to reduce the industry's total carbon dioxide emissions.[21] It is clear that India is actively seeking practical solutions and pathways for its transition from a 'Brown' economy to a 'Blue' one. Incorporating 'green' norms to underwater hull protection techniques could be a significant step to achieve the ambitious targets set by the country to reduce its GHG emissions.

Global Sustainable Underwater Hull Protection Trends:

Underwater-hull protection systems have dual purpose of protecting of the hull from fouling and also reducing the surface roughness. Increasingly stringent environmental regulations and the imperative to lower fuel consumption to not only reduce operating costs but also as one of the

practical measures to reduce carbon dioxide emissions have provided an impetus to the development of new anti-fouling technologies.[22] One of the more promising developments includes a hydrophilic anti-fouling coating based on hydrogel technology that comprises a network of advanced polymer chains, which can absorb necessary amounts of water to create water-like boundary and thereby reduce or prevent adherence of marine organisms to ship's hull. The creation of this water-like boundary effectively reduces hydrodynamic drag.[23] In addition, air lubrication systems — both passive and active — also hold out tremendous promise as practical commercial applications for sustainable underwater-hull protection. The authors undertook an extensive review of existing literature to identify various new trends in sustainable underwater-hull protection practices and conducted several interviews with the practitioners in the shipbuilding and ship repair industry to understand the nuances involved in practical commercial adoption of these new technologies. Online interaction and email exchanges with laboratories/companies were educative and informative. Based on the literature survey and interaction with stakeholders, the authors narrowed down their choice to two technologies/companies that are discussed in the ensuing paragraphs.

AIRCOAT. The AIRCOAT[24],[25] is a Horizon 2020 project that received a total grant of 5.3 million Euros from the European Commission. AIRCOAT is an abbreviation for 'Air Induced friction Reducing ship COATing' and the project aims at developing a biomimetic antifouling coating — a biomimetic antifouling coating is a treatment that prevents the accumulation of marine organisms on a surface. Typical antifouling coatings are not biomimetic but are based on synthetic chemical compounds that can have deleterious effects on the environment. On the other hand, natural materials such as sharkskin continue to provide inspiration for scientists to improve

the coatings currently in the market[26] — passive air lubrication technology that avoids direct contact of the ship and water, which reduces drag, corrosion and fouling of the hull and may lead to significant fuel savings at global level. The passive air lubrication technology is based on a biomimetic ship hull coating that introduces a permanent layer of air on a surface under water, inspired by the 'Salvinia effect'. The Salvinia effect uses a hierarchically structured surface with specialised micro- and nano-structures, in combination with hydrophilic and hydrophobic areas. The structure mimics the biochemical processes of the Salvinia plant, which allow long-term air retention and prevent air-loss even in turbulent flow conditions.[27] The effect enables the trapping of air through this structured surface. This technology can be implemented by using a self-adhesive foil system. Although this product is not yet commercially available, it has the potential to revolutionise the entire hull-coating process. The layer of air created in ship's hull area that lies 'between wind and water' serves as a slip agent, increasing the velocity at the phase boundary layer. This, in turn, leads to reduced shear stress and, ultimately, reduced skin-friction. A friction coefficient reduction between 2 and 20 per cent has been observed in different experimental scenarios conducted by the AIRCOAT team, as reported in email exchanges/online interaction between the authors and the team.

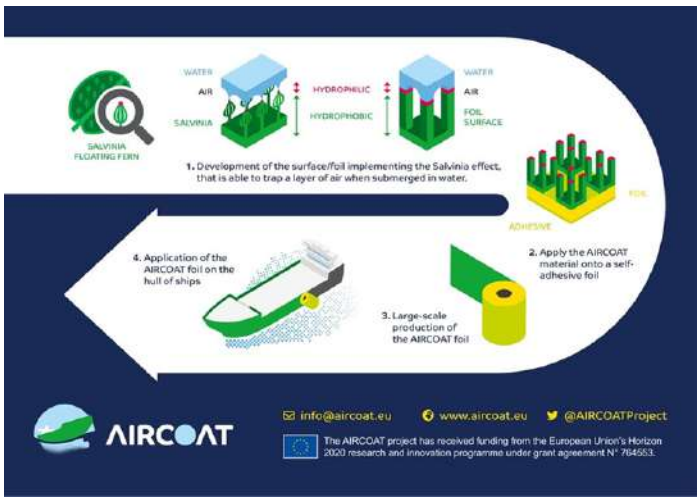


Image Source: AIRCOAT[28]

Silverstream Technology. Silverstream Technology [29],[30] is a market leader in air lubrication systems for the shipping industry. They have patented an air-lubrication system called the 'Silverstream® System', which essentially involves the release of pressurized air from Air Release Units (ARUs) in the hull to create a uniform carpet of microbubbles that coats the entire length of the vessel's keel and decreases frictional resistance between the vessel's hull and the water, thereby reducing both, fuel consumption and GHG emissions. The system harnesses the power of both, compressed air and the ocean, to deliver between 5 and 10 per cent fuel and emissions savings. Since the firm undertakes the complete process from the design stage to fitment, trials and system handover, the system is suitable for both, new construction vessels, as also for retrofitting onboard vessels that are already in service. In the case of a retrofitment, all structural integration work can be completed during the normal dry-docking period. In compliance with IMO's Energy Efficiency Existing Ship Index (EEXI) for newly constructed vessels and the Energy Efficiency Design Index (EEDI) for existing vessels, the air lubrication technology is advocated as a clean technology that significantly improves the aforementioned efficiency ratings.[31] The Silverstream® System is also well-suited to IMO's operational Carbon Intensity Indicator (CII) regulation, which mandates that ships of 5,000 gross tonnage and above must ensure a continuous improvement of the vessel's operational emissions output.[32] The Silverstream technology is fuel-agnostic and additionally reduces underwater fouling and radiated noise. The system is claimed to last the full lifecycle of the vessel and deliver efficiency gains by net fuel and emission savings, depending on the vessel type.

Ship Type	System Operational Speed (KTS)	Typical Operational Draught (M)	Flat Bottom as a percent of total wetted surface area	Net Savings Silverstream system performance
Cruise Ship	10-20	8-9	30-35 %	5-7 %
New Generation RoRo	10-22	7-8	26-32 %	5-7 %
Containership (>9,000 TEU)	10-23	14-16	25-30 %	5-6.5 %
Gas Carriers (LNGC, VLECs and VLGCs)	10-19	9-12	35-40 %	6-9 %
Large Wet & Dry Bulk Carrier (> 100k DWT)	10-15	13-20	25-45 %	6-11 %

Table 2: Net Savings by the use of Silverstream system for different types of vessels at specific operational speed and draught.
Source: Silverstream Technology [33]

AIRCOAT, Silverstream® System and Anti-fouling paints — A Comparison

The authors divided the project into two phases. In the first phase, they undertook a comprehensive literature review and desk-based research. The second phase included interviews and interactions with a variety of stakeholders in the field of improving hull coatings. A substantial amount of data was collected by means of questionnaires, to understand the underwater hull protection technology market and its development with respect to time. The authors have tabulated below their appreciation of critical parameters relevant to the three potential applications discussed in this paper, and their appreciation is based on interactions with major Indian shipyards and companies working towards sustainability in the maritime sector, including inputs provided by the AIRCOAT and the Silverstream teams.

Factors	Anti-fouling paints	AIRCOAT	Silverstream® System
Applicability	Applicable on all hull forms	Applicable on all hull forms	Applicable for flat bottom hull forms only
Application process and ease of application	A paint scheme is applied on the hull with specific film thickness and inter-coat drying intervals. Standard Operating Procedures (SOPs) exist for application of paint scheme.	A foil is stuck on the hull. Difficult to implement because presently the procedure is manual and there are limitations of adhesiveness, environmental conditions like humidity etc. and size of foils.	Air Release Units (ARUs) are installed in the vessel that uses air compressors and air outlet in the hull to release air bubbles constantly. Can be fitted without much difficulty.
Extra cargo space and energy required	No	No	Yes, it requires extra energy for compressed air supply and occupies some cargo space
Noise pollution	Does not contribute to underwater noise reduction	Reduces underwater noise from vessel	Reduces underwater noise from vessel
Anti-fouling property	Chemicals present in the paint have anti-fouling property	Formation of a passive air layer prevents fouling.	Formation of active air bubble layer at wetted surface area prevents fouling.
Marine ecotoxicity and eutrophication	The chemicals from the paint adversely affect the marine ecosystem	Eco-friendly	Eco-friendly
Initial Cost	Lower than AIRCOAT and Silverstream® System	Higher than anti-fouling paints	Higher than anti-fouling paints
Overall Effectiveness	Lower performance	Better performance but maintaining the passive air layer constantly is difficult	Better performance than normally painted hull vessel
Commercial availability	Yes, readily available	No, still in laboratory phase	Yes

Table 3: Compares the three systems that can be used for underwater hull protection. Source: Collated and analysed by Authors

Discussion

AIRCOAT is a 'passive' air-lubrication system whereas Silverstream® System is an 'active' one. Unlike active air lubrication technologies, AIRCOAT has no limit with respect to hull forms whereas the Silverstream® System is preferred for flat bottoms. The latter consumes energy to ensure the supply of compressed air and modifications are undertaken during maintenance periods to provide air outlets in the hull and the fitment of air compressors and associated auxiliaries, air reservoirs and piping, thereby consuming some cargo space. However, the energy and space penalties are negligible compared with the overall savings that accrue. During their interaction with the authors, the AIRCOAT team stated that based upon the several experiments undertaken to analyse the performance of the AIRCOAT system in a marine environment, they had deduced a 10 per cent reduction in friction and were able to validate the entire experiment by numerical simulation. Currently, the AIRCOAT system is yet to mature commercially and still has some challenges to overcome. The Silverstream® System, on the other hand, is already available commercially and has also demonstrated its efficiency in actual field settings, with a saving of 5-10 per cent in terms of fuel and GHG emissions. Both, AIRCOAT and the Silverstream® System are environmentally friendly and have negligible adverse effects on the marine ecosystem when compared with anti-fouling paints. They also have the additional advantage of reducing fuel consumption and GHG emissions. However, the application of AIRCOAT or the Silverstream® System is capital-intensive and costlier than the application of anti-fouling paints.

Recommendations for the Indian Shipbuilding and Ship Repair Industry

In accordance with Maritime India Vision 2030[34], the authors recommend the following:

- Active Air Lubrication Technology, which is commercially available, may be considered as an immediate step towards decarbonisation.
- Implement a gradual phasing-out of biocidal anti-fouling paints.
- Intensify research and development efforts in Indian academia and laboratories to find better alternatives for sustainable Underwater Hull Protection Practices.

Conclusion

The clock is ticking fast for the maritime industry to meet the stringent emission regulations. Maximising vessel efficiency, irrespective of fuel choice, is a crucial factor to reduce operating costs and ensure profitability. Thus, the authors feel that analysing different sustainable practices for underwater hull protection is an important step towards decarbonisation. The potential of sustainable underwater hull protection practices needs more study and research with respect to Indian shipbuilding and ship-repair practices.

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[1] Hoesung Lee et al, "Synthesis Report of The IPCC Sixth Assessment Report (Ar6)", Intergovernmental Panel on Climate Change (IPCC), 2023. https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf

[2] "IMO'S work to cut GHG emissions from ships", International Maritime Organisation (IMO), accessed on 10 February 2023 https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx

[3] Ibid.

[4] Naida Hakirevic Prevljak, "IMO, Norad embark on new biofouling project", Offshore energy, 16 December 2021 https://www.offshore-energy.biz/imo-norad-embark-on-new-biofouling-project/

[5] "GloFouling Partnerships", accessed on 28 February 2023 https://www.glofouling.imo.org/objectives

[6] "Analysing the impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures", GEF-UNDP-IMO GloFouling Partnerships Project, 2022 https://www.glofouling.imo.org/_files/ugd/34a7be_02bd986766d44728b85228c3ec9b95ee.pdf

[7] Hyun-Jeong Kim, “Strategic actions for sustainable vessel hull coatings in line with the UN SDGs”, Journal of Advanced Marine Engineering and Technology, The Korean Society of Marine Engineering, August 2021
The Korean Society of Marine Engineering (e-jamet.org)
[8] International Maritime Organization (IMO), Accessed 28 February, 2023
https://www.imo.org/en/OurWork/Environment/Pages/Anti-fouling.aspx
[9] Hyun-Jeong Kim, “Strategic actions for sustainable vessel hull coatings in line with the UN SDGs”, August 2021
The Korean Society of Marine Engineering (e-jamet.org)
[10] Ibid
[11] “2011 Guidelines for the Control and Management of Ships’ Biofouling to Minimize the Transfer of Invasive Aquatic Species”, Resolution MEPC.207(62), ANNEX 26, International Maritime Organisation (IMO), 15 July 2011.
https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/RESOLUTION%20MEPC.207[62].pdf
[12] International Maritime Organisation (IMO), Accessed 28 February, 2023
https://www.imo.org/en/OurWork/Environment/Pages/Biofouling.aspx
{13] “Analysing the impact of Marine Biofouling on the Energy Efficiency of Ships and the GHG Abatement Potential of Biofouling Management Measures”, GEF-UNDP-IMO GloFouling Partnerships Project, 2022
https://www.glofouling.imo.org/_files/ugd/34a7be_02bd986766d44728b85228c3ec9b95ee.pdf
[14] “Ban on use of Anti-Fouling Systems that contains Cybutryne”, Technical Circular No: 019/2022, Indian Register of Shipping (IR CLASS), 2022
IRCLASS- Technical Circular No: 019/2022
[15] S.N.Batra, A Guide to Hull Painting of Ships (Marine Insight, 2014), 106
[16] Ministry of Ports, Shipping and Waterways, accessed on 1 March 2023
https://shipmin.gov.in/division/shipping

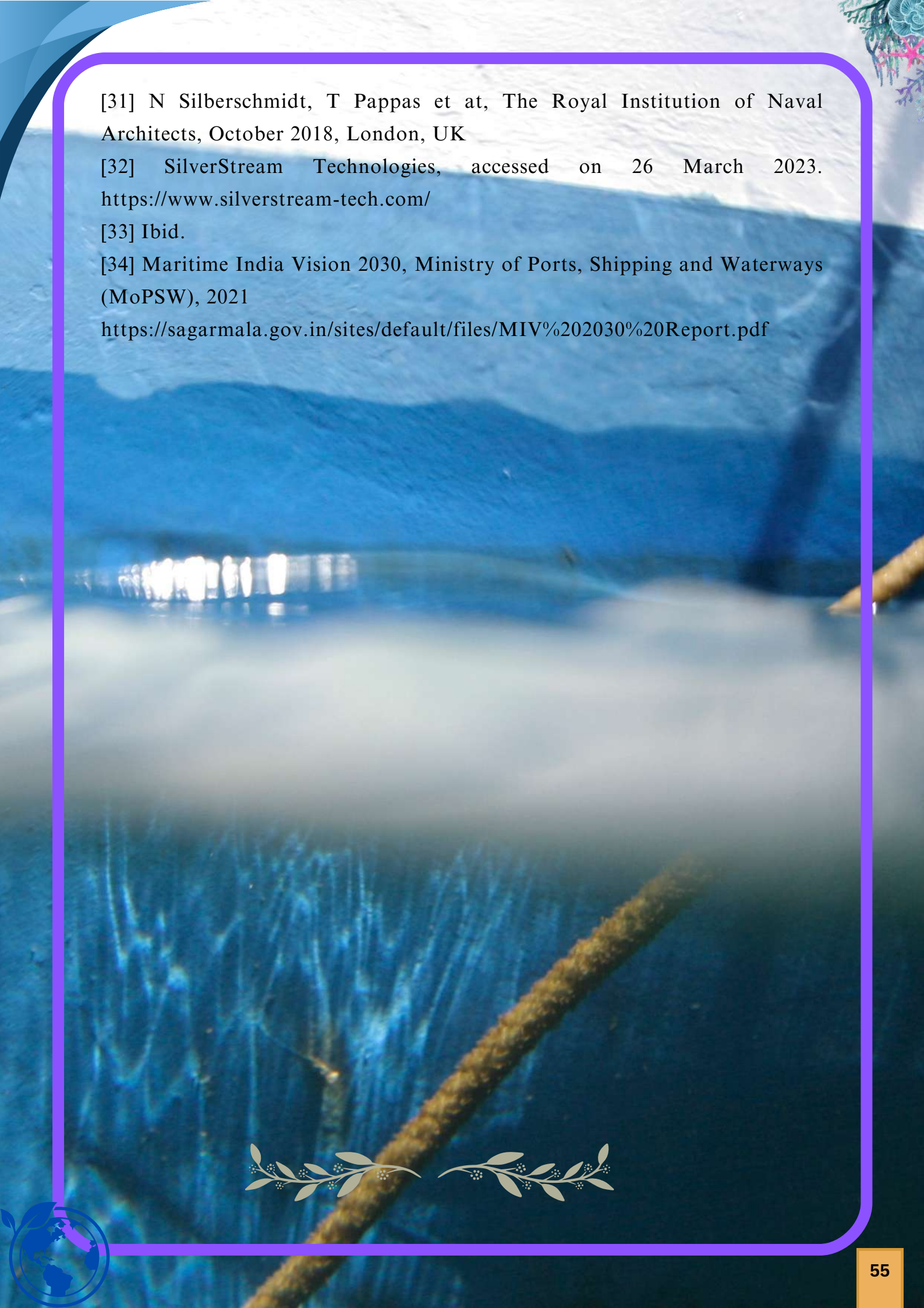
[17] “Statistics of India’s shipbuilding and ship repairing industry 2021-22”, Transport Research Wing, Ministry of Ports, Shipping and Waterways (MoPSW), Government of India (GOI), New Delhi, February 2023
https://shipmin.gov.in/sites/default/files/SBR%202021-22%20Final.pdf
[18] Ibid
[19] Bu, H.; Yuan, X.; Niu, J.; Yu, W.; Ji, X.; Lyu, H.; Zhou H., “Ship Painting Process Design Based on IDBSACN-RF”, Coatings 2021.
https://doi.org/10.3390/coatings11121458
[20]Joshi, Ankur & Kale, Saket & Chandel, Satish & Pal, Dinesh, “Likert Scale: Explored and Explained”, British Journal of Applied Science & Technology. 7. 396-403. 2015
[21] “Maritime India Vision 2030”, Ministry of Ports, Shipping and Waterways (MoPSW), Government of India
[22] Abdullah Saif Qureshi, Dr. Rajan Ramaswamy, “Evolution of anti-fouling paints”, International Journal of Science and Research (IJSR), 2015
[23] Ibid
[24] Johannes Oeffnera, Jukka-Pekka Jalkanenb, Stefan Walheimc, Thomas Schimmelc, “From nature to green shipping: Assessing the economic and environmental potential of AIRCOAT on low-draught ships” Proceedings of 8th Transport Research Arena TRA 2020, Helsinki, Finland, April 27-30, 2020
[25] AIRCOAT, accessed on 26 March 2023, https://aircoat.eu/
[26] J.Busch , W Barthlott, M.Brede, W.Terlau, M. Mail, “ Bionics and green technology in maritime shipping: an assessment of the effect of Salvinia air-layer hull coatings for drag and fuel reduction”, The Royal Society Publising , 9 October 2018.
http://dx.doi.org/10.1098/rsta.2018.026
[27]Ibid.
[28] AIRCOAT, accessed on 26 March 2023, https://aircoat.eu/
[29] N Silberschmidt, T Pappas, D Connolly and L De Freitas, “Full Scale Performance Measurement and Analysis of the Silverstream Air Lubrication System”, The Royal Institution of Naval Architects, October 2018, London, UK
[30] SilverStream Technologies, accessed on 26 March 2023. https://www.silverstream-tech.com/

[31] N Silberschmidt, T Pappas et at, The Royal Institution of Naval Architects, October 2018, London, UK

[32] SilverStream Technologies, accessed on 26 March 2023. https://www.silverstream-tech.com/

[33] Ibid.

[34] Maritime India Vision 2030, Ministry of Ports, Shipping and Waterways (MoPSW), 2021 https://sagarmala.gov.in/sites/default/files/MIV%202030%20Report.pdf



Climate Change Resilience in Coastal Communities in India

By: Jayant Sharma, Consultant

Image Source : (NMF, 2020)

India has a rich heritage of judiciously harnessing natural resources, and maintaining a harmonious equilibrium between humanity and the environment. Coastal regions, featuring mangroves, coral reefs, seagrass, dunes, forested watersheds, and salt marshes, play a pivotal role in sustaining fisheries, aquaculture, forestry, and household necessities. These ecosystems not only shield coastal communities from storm surges and turbulent tides but also underpin the livelihoods of many through the fishing industry. However, the delicate ecosystem faces significant challenges due to human activities as well as Climate Change, which are increasingly affecting India's coastal communities and their vital ecosystems.

With a coastline spanning over 7,500 km (5,423 km in peninsular India and 2,094 km in the Andaman, Nicobar and Lakshadweep Islands), almost 3.5 per cent of the world's population resides within 50 km of the coast (United Nations, n.d.).

In India, out of the 13 coastline States/Union Territories/Islands, coastal populations in the three most vulnerable States, namely Andhra Pradesh, Maharashtra and Odisha, are highly dependent on the ecological health of coastal ecosystems for their livelihoods.

Climate Change risks and impacts

India faces severe Climate Change impacts, including three primary concerns i.e. rising sea levels submerging valuable land, rising air and water temperatures posing health and ecosystem risks, and unpredictable and erratic rainfall patterns.

Sea levels in India have risen by an average of 1.3 mm per year (Ministry of Environment and Forests November 2010), and the Intergovernmental Panel on Climate Change (IPCC) report predicts further increases by 2050 (Deccan Herald 2022). Coastal regions in India are expected to experience temperature rises of 1.6°C to 2.1°C compared to the 1970s (Ministry of Environment and Forests, GoI 2010). Globally, ocean temperatures have increased significantly since 1950, with the Indian Ocean experiencing 2-3 times more warming than the tropical Pacific (Sumit Panja n.d.). This has led to variations in rainfall patterns, including a decline in monsoon rainfall since the 1950s and an increase in heavy rainfall events, contributing to both droughts and flooding in different parts of India, notably along the north-west and south-eastern coasts (World Bank 2013).

The compounding consequences of the Climate Change risks and impacts outlined above have placed food and water security, public health, as well as the lives and livelihoods of over 190 million people residing along India's coastlines in threat (Amit Garg, 2015).

Coastal ecosystem fights against Climate Change

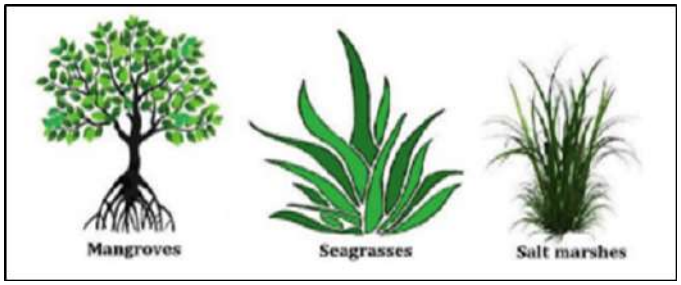


Image Source: (Abhra Chanda 2022)

India has a highly productive coastal ecosystem covering approximately 5000 km² of mangroves, 1600 km² of salt marshes, 500 km² of seagrass ecosystems, and 2300 km² of coral reefs (Abhra Chanda 2022).

These ecosystems serve as crucial barriers against storm surges and rising sea levels, maintain coastal water quality, provide vital habitats for marine life, offer sustenance to coastal communities, and deliver essential ecosystem services supporting rural livelihoods. This ecosystem is vital for the well-being of coastal communities in India.

Enhancing the climate resilience of India's coastal communities

It is increasingly clear that bolstering the resilience of Indian coastal communities against Climate Change demands significant investment in ecological infrastructure. This investment is essential to enhance the supply of ecosystem goods and services to these communities. Such provisions serve a dual purpose: safeguarding infrastructure against storm surges triggered by cyclones and ensuring the sustainability of various natural resource-based livelihoods in the face of Climate Change.

The well-being of coastal communities requires sustainable, practical practices and traditions. To address these issues, the Green Climate Fund (GCF) is financing the project "Enhancing Climate Resilience of India's Coastal Communities" executed by the Ministry of Environment, Forest and Climate Change (MoEFCC) in collaboration with the three most vulnerable States of India namely Andhra Pradesh, Maharashtra and Odisha as mentioned above. The United Nations Development Programme (UNDP) is the Accredited Entity for this initiative and the size of fund is $4,238,151 (United Nations, n.d.).

The project's objectives include:

1. Assessing coastal vulnerability to inform ecosystem and community-based adaptation planning in 13 coastal States/Union Territories/ Islands.
2. Conserving and restoring coastal ecosystems to enhance resilience in the three target States.
3. Integrating climate-adaptive livelihoods for enhanced resilience among vulnerable coastal communities.
4. Strengthening governance and institutional frameworks for climate-resilient coastal management.
5. Enhancing the capacity of local communities for community-based adaptation and climate-adaptive livelihoods.
6. Incorporating ecosystem-centric approaches to Climate Change adaptation into public and private sector plans and budgets while scaling up finance for Ecosystem-Based Adaptation (EBA) in 13 coastal States.

Project's Achievements

The project has benefited ten million people across 12 districts in three targeted states by enhancing the resilience of coastal ecosystems, safeguarding lives, livelihoods, and property from the intensifying impacts of Climate Change-related extreme weather events. Approximately 17,44,970 individuals in 24 designated areas, half of whom are women, have gained from the adoption of diversified, climate-resilient livelihood options. Furthermore, the project has protected and restored 14,945 hectares of coastal ecosystems, including mangroves, saltmarshes, seagrass beds, coral reefs, and coastal watersheds, to mitigate climate variability and change. Additionally, it has strengthened the capacity of coastal management institutions to plan and implement Climate Change adaptation measures, especially those focused on protecting and restoring ecological infrastructure (United Nations, n.d.).

Way Forward

To enhance the climate resilience of coastal communities, a more integrated planning approach is essential, requiring collaboration among various governments/ministries, the private sector, and civil society organisations. Strengthening technical and institutional capacity is crucial for mainstreaming Climate Change adaptation into development planning.

Awareness-raising and skills-development initiatives are necessary for promoting alternative livelihoods and community engagement in Indian coastal communities. Thus, investments in ecological infrastructure and coastal livelihoods must prioritise direct involvement with local communities.

The recommended interventions require a paradigm shift, urging the public and private sectors to adopt ecosystem- and community-based approaches to enhance the resilience of coastal communities to Climate Change. To enable this transformation, it is vital to: (i) promote cross-sectoral planning and governance; (ii) ensure full community participation; (iii) invest in ecological infrastructure and climate-resilient livelihoods; (iv) disseminate knowledge on EbA; (v) adjust policies and regulatory frameworks to encourage investments in EbA and livelihoods; and (vi) build the capacity of both government and communities to implement EbA.

In summary, building resilience in Indian coastal communities involves: (i) safeguarding and restoring ecosystems like mangroves, seagrass beds, coral reefs, salt marshes, and coastal dunes, along with their services; (ii) assisting communities in enhancing their adaptive capacity through awareness training, financial support, and livelihood strengthening; and (iii) integrating EbA into coastal management efforts led by public and private sector actors nationwide.

Bibliography

Abhra Chanda, Tuhin Ghosh. 2022. "Blue Carbon Potential of India: The Present State of the Art." 159-180. Accessed November 6, 2023 .https://www.researchgate.net/publication/364524131_Blue_Carbon_Potential_of_India_The_Present_State_of_the_Art.

Amit Garg, Vimal Mishra, Hem H. Dholakia. 2015. "Climate Change Hange and India Adaptation Gap." Research and Publications, INDIAN INSTITUTE OF MANAGEMENT, AHMEDABAD. Accessed November 02, 2023. https://www.iima.ac.in/sites/default/files/rnpfiles/10071603592015-11-01.pdf.

Deccan Herald. 2022. India's coastal cities may be inundated by 2050: Report. April 08. Accessed November 01, 2023. https://www.deccanherald.com/india/indias-coastal-cities-may-be-inundated-by-2050-report-1098840.html.

Ministry of Environment & Forests. November 2010. "CLIMATE CHANGE AND INDIA: A 4X4 Assessment: A SECTORAL AND REGIONAL ANALYSIS FOR 2030." Indira Gandhi National Forest Academy, Dehradun, India. Accessed November 02, 2023. https://www.ignfa.gov.in/document/reading-material-climate-change-and-india.pdf.

Ministry of Environment & Forests, GoI. 2010. "Climate Change in India." MoEFCC, GoI. Accessed November 03, 2023. https://www.ignfa.gov.in/document/reading-material-climate-change-and-india.pdf.

NMF. 2020. October.https://maritimeindia.org/climate-change-impact-on-mangrove-ecosystems-in-indias-coastal-regions/.

Sumit Panja, Anirban Kundu, Dr. Sayani Mukhopadhyay. n.d. "Climate Change impact on the coastal areas of India: A Review." Government College in Kolkata, India. Accessed November 03, 2023.https://asutoshcollege.in/new-web/pdf/envs-magazine/5.11%20Climate%20Change%20Impact%20on%20Coastal%20Areas%20of%20India%20A%20Review%20by%20Sumit%20Pania,%20Anirban%20Kundu,%20Dr.%20Sayani%20Mulhopadhyay.pdf.

United Nations. n.d. Enhancing Climate Resilience of India's Coastal Communities. Accessed October 31, 2023. https://www.undp.org/india/projects/enhancing-climate-resilience-india%E2%80%99s-coastal-communities.

—. n.d. United Nations Development Programme. Accessed November 01, 2023. https://www.undp.org/india/projects/enhancing-climate-resilience-india%E2%80%99s-coastal-communities.

World Bank. 2013. "India: Climate Change Impacts." Accessed November 02, 2023. https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change-impacts

Blue Economy

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Introduction: Blue Economy refers to all economic activities that take place in and around the world's oceans, seas and coasts. Marine and coastal environments constitute a key resource for economic development in the world, valued at US$ 1.5 trillion in 2010 may reach up to US$ 3.0 trillion by 2030. Oceans cover around 72 per cent of the earth's surface and provide food to around 600 million people worlds over, more than 80 per cent of global trade and commerce take place through oceans. The Blue ecosystem causes carbon sequestration, valued at US$ 190.0 billion per year in terms of blue carbon wealth and stores up to 10 times more carbon than the tropical rain forests.

The Blue Economy requires resilient systems, persistent innovations and advances in achieving integrated ecological, economic and social benefits. The pillars for transforming the traditional "Ocean and marine economy" to a "Blue" or "Sustainable" economy require appropriate governance for sustained utilisation of the ocean, coastal and marine economies, vision, technology, management, monitoring and time-bound regulatory frameworks.

International Conventions and Laws: For sustainable exploitation of seas and oceans and mitigation of maritime conflict, the United Nations Convention on the Law of the Sea (UNCLOS III) was adopted in 1982 which came into force in 1994. The convention covers various aspects of maritime affairs, including navigational rights, territorial seas, Exclusive Economic Zones (EEZs), continental shelves, deep-seabed mining, marine scientific research, and the protection and preservation of the marine environment.

Coastal states were vested with sovereignty over a belt of sea adjacent to their coastlines, known as the territorial sea where they can exercise control and regulate various activities, and EEZ with sovereign rights over the resources in the EEZ, which extends up to 200 nautical miles from their baselines, though other states enjoy the freedom of navigation and overflight in these zones. UNCLOS established the International Seabed Authority (ISA) to regulate activities related to the exploration and exploitation of mineral resources in the deep seabed beyond national jurisdiction.

The United Nations Organisation has proclaimed a "Decade of Ocean Science for Sustainable Development (2021-2030)" to support efforts to reverse the cycle of decline in ocean health and to take all ocean stakeholders worldwide along with a common framework to ensure support for sustainable ocean developments.

India has a vast coastline that spans approximately 7,517 km, including 1,962 km of Andaman and Nicobar Coast and 132 km of Lakshadweep coast, making it the seventh-longest coastline in the world. The country is surrounded by several bodies of water, including the Arabian Sea to the west, the Bay of Bengal to the east, and the Indian Ocean to the south. 250 million people live within 50 km of the coasts and supports 30 per cent of the population.

The Ministry of Earth Sciences, Government of India is the Nodal Ministry in matters of planning, research, management and implementation of policies and programmes of the Government of India and the Department of Fisheries, Ministry of Defence, Ministry of Ports, Shipping and Waterways, Ministry of New and Renewable Energy, Ministry of Environment, Forest and Climate Change, Ministry of Commerce, Ministry of Tourism, Ministry of Petroleum and Natural Gas, Ministry of Education and Ministry of Skill Development and Entrepreneurship, Industry bodies like Federation of Indian Chambers of Commerce and Industry (FICCI), Confederation of Indian Industry (CII) etc. are other stakeholders.

India's Maritime Laws and Regulations: India has established several laws and regulations to govern its marine and coastal areas, as well as activities in the surrounding oceans and seas, which provide legal framework for marine, coastal, and sea-related activities. Of which, The Territorial Waters, Continental Shelf, EEZ and Other Maritime Zones Act, 1976: grants India sovereignty over its territorial waters (up to 12 nautical miles from the baseline), rights over the continental shelf (up to 200 nautical miles), and rights over EEZ (up to 200 nautical miles), the Maritime Zones of India Notification, issued under the Territorial Waters Act: outlines specific coordinates and geographical points that demarcate India's territorial waters, contiguous zone, EEZ, and continental shelf.

National Maritime Policy: India's National Maritime Policy provides a comprehensive framework for the development and management of the country's maritime sector. It covers various aspects, including shipping, shipbuilding, ports, maritime security, and marine environment.

Issues and challenges faced by Blue Economy: The Blue Economy, which involves the sustainable use of ocean resources for economic development, faces a range of challenges/issues that need careful consideration and management.

In the year 2012, fish valuing US$ 83 billion was harvested. Such overfishing reduced harvest by 15 per cent and reduced price of landed fish by 33 per cent, and involved 52 per cent higher fishing cost. Use of deep fishing nets and fish attracting lights by developed countries is also causing tremendous harm to marine biodiversity, besides, damaging sea beds. Overfishing and deep sea catch is a serious cause of concern, as it depletes fish stocks, disrupts marine ecosystems, and threatens the livelihoods of communities dependent on fisheries. Similarly, Illegal, Unreported and Unregulated (IUU) Fishing is further undermining efforts to manage and conserve fish stocks. It often involves vessels operating outside national and international regulations, contributing to overfishing, economic losses, and social issues for legal fishers.

Pollution from various sources, including land-based runoff, industrial discharges, and marine litter (especially plastic), poses a significant threat to marine ecosystems. 13 coastal states and Union Territories generate 20,542 million litres per day (MLD) of net sewage, 70 x 107 cum of industrial waste, all homestead waste of 354 cities/towns along 148 polluted river stretches. Similarly, in sediments, total petroleum hydrocarbon (TPH) was found highest (8402 µgm/kg) off Ennore and Chennai ports. This pollution severely harms marine life, degrade water quality, and negatively impact human health, as well as industries such as tourism and fisheries.

Impact of Climate Change on Oceans: The impact of Climate Change on the oceans includes sea temperatures, ocean acidification which is currently 8.1 in the pH scale, emission of Greenhouse Gases (GHG) increasing from 10.9 billion tonnes per year in 1960s to about 36.6 billion tonnes per year in 2022, This GHG is absorbed by oceans increasing water acidification threatening fisheries and aquaculture and causing changes in weather patterns. The level of nitrous oxide increased by 1.24 ppb to 335.7 ppb in 2014 the third largest jump since 2000 due to increased use of nitrogenous fertiliser and manure. These changes affect marine ecosystems, including coral reefs, fish migrations, and heterogenous distribution of marine species, coastal plantations, mangrove density depletion, impacting the sustainability

of the blue economy. The degradation of marine habitats, over-exploitation of species, and the effects of Climate Change contribute to the loss of marine biodiversity. The number of dolphins and whales has reduced drastically over the years. As of July 2023, the number of dolphins and whales on Indian coast covering Andhra Pradesh, Odisha and West Bengal was 2703 and 4 only. The number of Dugongs in Gulf of Kutch, Gulf of Mannar,

Palk Bay and Andaman and Nicobar has gone down to around 200 only, as compared to a worldwide population of about 1,00,000. These have cascading effects on ecosystems and disrupt the balance of marine life, affecting fisheries and other industries.

Coastal Development and Resource Conflicts: Coastal development, including urbanisation, infrastructure projects, and habitat alteration, resulted in destruction of critical marine habitats such as mangroves, seagrasses, and coral reefs. Coral reef of 59 per cent in the Indian Ocean, 35 per cent in the Middle East, 34 per cent in south-east and east Asia, 22 per cent in the Caribbean and Atlantic Ocean and seven per cent in the Pacific Ocean have been destroyed (1998). Loss of these habitats impacts fish nurseries, coastal protection, storm protection and overall ecosystem health.

Competition for marine resources leads to conflicts among different user groups, including fisheries, shipping, tourism, and conservation interests. Effective governance and conflict resolution mechanisms are essential for addressing these competing interests and ensuring sustainable resource use.

Inadequate infrastructure, including ports, transportation, and energy facilities, also hinders the development of sustainable maritime activities. Investments in infrastructure that align with sustainability goals are crucial for the success of the blue economy.

Social Impact: The benefits of the Blue Economy are not always distributed equitably, leading to social and economic disparities. Some communities may experience displacement, loss of traditional livelihoods, or exclusion from decision-making processes related to ocean resource management.

The development of new technologies for activities such as deep-sea mining and aquaculture presents both opportunities and risks. Ensuring that these technologies are environmentally sustainable, socially just, and economically viable and essential for the sustainable development of the blue economy.

Solutions for challenges faced by Blue Economy sector

Addressing the issues facing the Blue Economy requires a comprehensive and collaborative approach involving governments, industries, communities, and international organisations with an intent to:

• Implement and enforce science-based fisheries management practices, including setting and enforcing catch limits, combating IUU fishing through improved monitoring, surveillance, and international cooperation, by promote the adoption of selective and sustainable fishing gear; strengthen and enforce regulations on industrial discharges, land-based runoff, and reducing marine litter, promote waste management and recycling initiatives to reduce the flow of plastics and other pollutants into the oceans; encourage research and development on innovative technologies for cleaning up of existing marine pollution, by supporting and implementing measures to reduce greenhouse gas emissions in line with international climate agreements;

- Implement strategies to reduce ocean acidification, heavy metal discharge and total hydrocarbon sediments;
- Establish and expand Marine Protected Areas (MPAs) to conserve critical habitats and safeguard biodiversity;
- Support and fund research by coastal and marine spatial planning to prevent the destruction of mangroves, seagrasses, and coral reefs;
- Develop and strengthen governance frameworks at local, national, and international levels for integrated ocean management;

- stablish mechanisms for stakeholder engagement, including the participation of local communities and indigenous groups;
- Implement conflict resolution processes to address competing interests in the use of marine resources;
- Invest in sustainable maritime infrastructure, including ports, transportation, and energy facilities;
- Integrate climate resilience considerations into infrastructure planning to address the impacts of sea-level rise and extreme weather events.

The success of these remedies depends on the commitment of all stakeholders to sustainable practices, effective governance, and ongoing collaboration to address the interconnected challenges facing the Blue Economy.

Floating Solar Farms: An Innovative Approach to Maximise Solar Energy Generation

By: Vikas Dhir, AAO

Floating Solar Panels, Image Source: (The Economic Times, 2023) at
https://economictimes.indiatimes.com/industry/renewables/how-floating-solar-panels-are-being-used-to-power-electric-grids/articleshow/98481826.cms?from=mdr

Introduction: The global impact of Climate Change is becoming increasingly evident, with its alarming pace and severity. This is particularly concerning for emerging and developing economies, which are more vulnerable due to their limited technological capabilities and financial resources for climate adaptation and mitigation. However, there has been a significant increase in climate action, with governments worldwide focusing on renewable and sustainable energy to mitigate adverse environmental effects.

Marine renewable energy encompasses various renewable energy technologies installed and operated at sea, requiring offshore grid and distribution systems. This category includes technologies such as offshore wind, tidal stream, tidal range, and wave energy, as well as the emerging practice of floating photovoltaic energy, which involves installing solar panels on the surface of water bodies.

Advantages of Floating Solar System

Water Bodies: When photovoltaic (PV) modules are positioned on water bodies; they benefit from a cooling effect that significantly boosts their efficiency when compared to ground-based PV systems. This cooling effect, generated by the circulation of cool air beneath the PV modules, is a distinct advantage of Floating Photovoltaic (FPV) systems over ground-based PV (GPV) systems.

What are Floating Solar Photo Voltaic Plants?: Floating solar photovoltaic (PV) plants are an innovative type of PV system designed to float on various water bodies, including irrigation canals, water reservoirs, quarry lakes, and tailing ponds. These systems have been implemented in several countries, including France, India, Japan, Korea, the United Kingdom, and the United States (Patil (Desai) Sujay S., 2017).

Energy Efficiency: Research conducted in Visakhapatnam, India, revealed a notable 1.5–3 per cent increase in energy production for FPV systems when contrasted with GPV systems (Hema Bala, 2021). The World Bank conducted a comprehensive study and identified varying efficiency improvements ranging from 5 per cent to 10 per cent for different climatic regions (Ghosh, 2022).

Water Evaporation: Furthermore, FPV systems have demonstrated a remarkable ability to mitigate water evaporation. A comprehensive study is focused on assessing the impact of FPV systems on five major reservoir lakes in Iran (Mohammad Fereshtehpour a, 2021). It has been observed in a research study that, by covering only 10 per cent of the five main reservoir lakes with FPV systems, enough water would be saved from evaporation to fulfill the domestic water needs of a city with one million inhabitants (Ghosh, 2022).

Chlorophyll and Nitrate: It has been observed in a study that installation of FPV not only leads to water savings but also results in enhanced concentrations of chlorophyll and nitrate, along with a substantial 60 per cent reduction in water evaporation (Abdelal, 2021).

Negative Impacts of Floating Solar Photovoltaic Systems

- Potential risks such as sudden or gradual releases of chemicals, as well as oil/fuel leakage into water from PV panels.
- Maintenance challenges in ensuring water cleanliness.
- Potential blockage of sunlight affecting underwater life, plants, and algae.

Conclusion:

Floating solar farms are redefining the possibilities of solar energy generation. By utilising water surfaces that were previously overlooked, these innovative systems address some of the most pressing challenges in the transition to renewable energy. With land conservation, water conservation, and enhanced efficiency as their key advantages, floating solar farms have the potential to revolutionise the energy landscape, offering a greener and more sustainable future for generations to come. As technology and infrastructure continue to improve, we can expect to see these floating marvels become a common sight on our water bodies, further advancing our commitment to a cleaner and more sustainable world.

Key Pointers of Audit with reference to Policies in India

When conducting an audit on FPV systems in India, it's essential to assess these systems in accordance with pertinent policies and regulations. The audit can scrutinise whether FPV projects adhere to national and state-level policies, including the National Solar Mission (NSM) and regional renewable energy policies. This audit examination can also extend to project selection and approval processes, ensuring that they align with guidelines from the Ministry of New and Renewable Energy (MNRE) and other State agencies. Additionally, the audit can evaluate environmental impact assessments, adherence to land and water resource usage policies, safety and quality standards established by the Bureau of Indian Standards (BIS) and the MNRE, financial viability compared to land-based solar projects, regulatory compliance, and energy generation performance in line with MNRE targets. The audit can also scrutinise water conservation effectiveness, maintenance schedules, and expected lifespans, along with community and stakeholder engagement, subsidies, incentives, disaster preparedness, security measures, and alignment with government policies regarding future expansion and research and development in the renewable energy sector. By conducting this comprehensive audit, it can be ensured that FPV systems are implemented in India in a manner that is compliant with relevant policies, sustainable, and in the best interest of the nation.

Bibliography

Abdelal, Q. (2021, January 22). Floating PV; an assessment of water quality and evaporation reduction in semi-arid regions. doi:https://doi.org/10.1093/ijlct/ctab001

Ghosh, L. E. (2022, June 29). Floating Photovoltaics: A Review. Retrieved October 31, 2023, from https://www.mdpi.com: https://www.mdpi.com/2571-8797/4/3/46

Hema Bala, S. P. (2021, November). Floating Solar Potential Assessment. Retrieved October 31, 2023, from https://ieeexplore.ieee.org/: https://ieeexplore.ieee.org/document/9687733

Mohammad Fereshtehpour a, R. J. (2021, June). Evaluation of factors governing the use of floating solar system: A study on Iran's important water infrastructures. Retrieved October 31, 2023, from https://doi.org/10.1016/j.renene.2020.12.005

Our World in Data. (2021). India: Energy Country Profile. Retrieved April 21, 2023, from https://ourworldindata.org/: https://ourworldindata.org/energy/country/india

Patil (Desai) Sujay S., W. M. (2017, June 06). A Review on Floating Solar Photovoltaic Power. Retrieved October 31, 2023, from https://www.researchgate.net/publication/347818468_A_Review_on_Floating_Solar_Photovoltaic_Power_Plants

The Economic Times . (2023, March 7). How floating solar panels are being used to power electric grids. Retrieved from https://economictimes.indiatimes.com/industry/renewables/how-floating-solar-panels-are-being-used-to-power-electric-grids/articleshow/98481826.cms?from=mdr

How Marine Protected Areas Are Central to Our Blue Economy?

By: Saurabh Sharma, AAO

What is a Marine Protected Area?

The world's coastal and marine ecosystems are facing significant threats as the ever-expanding human population heavily relies on marine resources. This has resulted in acute pressure on our delicate environment. Establishing Marine Protected Areas (MPAs) is considered one of the solutions for safeguarding the marine ecosystem. The establishment of MPAs is influenced by various international, regional, and national commitments and efforts; however, the primary authority overseeing guidelines and standards for MPAs is the International Union for Conservation of Nature (IUCN).

The IUCN has defined MPAs (World Commission on Protected Areas 1999) as “any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical, and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment”. These areas are meant to safeguard diverse ecosystems such as reefs, seagrass beds, shipwrecks, archaeological sites, tidal lagoons, mudflats, salt marshes, and mangroves, etc. Similar to terrestrial parks and protected areas, MPAs may be classified in different forms. They can differ in size and may have different permissible human activities. MPAs don't universally signify a complete prohibition of all activities or the exclusion of human presence, but sustainable resource utilisation stands as a fundamental pillar in achieving the objectives of marine conservation.

Coastal and Marine Protected Areas in India

India stands as one of the world's mega-diverse nations, as approximately 7-8 per cent of the documented global species found in India. Moreover, India remarkably represents four out of the 34 identified biodiversity hotspots globally (Convention on Biological Diversity, n.d.). India has an extensive coastline stretching 7,517 km in length, with 5,423 km along Peninsular India and 2,094 km encompassing the Andaman and Nicobar, and Lakshadweep Islands. The Government of India has undertaken several initiatives focusing on the conservation of coastal and marine resources, especially wetlands, mangroves, and coral reefs, and their management through the implementation of laws and continuous monitoring. MPAs in India are designated in accordance with the guidelines set by IUCN.

There are 25 MPAs in Peninsular India covering an area of 6,852.14 km². Additionally, there are 104 Marine Protected Areas in the Islands, with 100 in the Andaman and Nicobar Islands and four in the Lakshadweep Islands, covering areas of 1,594.78 km² and 270.06 km² respectively, with combined total of 1,864.84 km² (Wildlife Institute of India, Dehradun 2021).

India has made significant strides in meeting the Aichi Biodiversity Targets, notably focusing on Target 11, i.e., conserving at least 10 per cent of coastal and marine areas in protected area networks, and Target 14, i.e., restoring and safeguarding ecosystems vital for water, health, livelihoods, and well-being. In alignment with these objectives, the Wildlife Institute of India has identified and prioritised 106 Important Coastal and Marine Biodiversity Areas (ICMBAs) (K. Sivakumar n.d.).

Empowering India's Blue Economy: The Vital Role of Marine Protected Areas (MPAs)

As per a European Commission study, MPAs can play an essential role in fostering the Blue Economy by positively impacting fisheries, aquaculture, tourism, and the overall well-being of coastal areas (SAFETY4SEA 2018).

Similarly, MPAs in India have significantly contributed to advancing the country's Blue Economy by serving as strategic tools for managing natural marine resources. Their primary objectives include conserving biodiversity and ensuring the well-being of communities dependent on these resources. These are several areas where MPAs can significantly contribute to empowering the Blue Economy sector in India:

• **Preservation of Biodiversity:** MPAs act as sanctuaries for diverse marine ecosystems, safeguarding various species and habitats. By conserving these natural resources, they ensure the continued health and diversity of marine life, which is fundamental for ecological balance and sustainable economic development.

• **Sustainable Fisheries:** These protected areas serve as nurseries and breeding grounds for marine species, contributing significantly to the sustainability of fisheries. By allowing fish populations to thrive within these zones, they support the regeneration of fish stocks beyond their boundaries, which is essential for the fishing industry and food security.

• **Tourism and Recreational Opportunities:** MPAs attract tourists and enthusiasts interested in marine life and ecosystems. The pristine environments within these protected areas offer opportunities for activities such as snorkeling, diving, and wildlife observation, fostering tourism and creating economic prospects in the hospitality and recreation sectors.

• **Climate Resilience:** MPAs play a pivotal role in enhancing the resilience of coastal communities against the impacts of Climate Change. Healthy marine ecosystems within these areas serve as natural barriers, mitigating the effects of rising sea levels, storms, and erosion, thereby safeguarding coastal regions.

• **Scientific Research and Innovation:** These protected areas provide a platform for extensive scientific research. They allow experts to study marine ecosystems, biodiversity, and the impacts of human activities, fostering innovation and informing policies for sustainable resource management.

• **International Commitments:** India's dedication to establishing and maintaining MPAs aligns with global commitments towards ocean conservation and the sustainable use of marine resources. Collaborations with other nations and international organisations further these shared objectives.

Challenges and Way Forward

MPAs in India are facing a series of challenges that affect their effectiveness and sustainability. Balancing the conservation of marine resources with the needs of various stakeholders, such as fishermen and coastal communities, often leads to conflicts. Enforcing and ensuring compliance with regulations, especially in remote or hard-to-reach MPAs, presents a significant challenge.

Furthermore, there's a crucial need for comprehensive data collection and monitoring, as insufficient data can hinder decision-making. Climate Change effects, including rising sea levels and extreme weather, significantly threaten the stability of these areas. Insufficient public awareness and engagement hinder the protection and success of MPAs. Policy and regulatory gaps, along with the impact of unregulated tourism, invasive species, and the limited size and fragmentation of some MPAs, further challenge their effective management and conservation.

To address these challenges, there is a need of multi-faceted approach involving collaborations between government bodies, local communities, scientific endeavours, and international support which will focus on adequate funding, robust enforcement mechanisms, and sustainable management practices for the long-term success of MPAs in India.

In India's Blue Economy, MPAs can serve as guardians of marine biodiversity, supporting fisheries and conserving natural habitats. Overall, MPAs stand at the core of India's Blue Economy, balancing economic growth with the preservation of marine ecosystems for a sustainable and prosperous future.

Bibliography

Convention on Biological Diversity. India's Biodiversity Facts. n.d. https://www.cbd.int/countries/profile/?country=in (accessed November 08, 2023).

K. Sivakumar, V.B. Mathur, Anant Pande. "Coastal And Marine Protected Areas In India:Challenges And Way Forward." envis bulletin, n.d.

SAFETY4SEA. Marine Protected Areas can boost Blue Economy, report notes. November 27, 2018. https://safety4sea.com/marine-protected-areas-can-boost-blue-economy-report-notes/ (accessed November 08, 2023).

Wildlife Institute of India, Dehradun. Marine Protected Areas. April 12, 2021. https://wiienvis.nic.in/database/mpa_8098.aspx (accessed November 08, 2023).

World Commission on Protected Areas. Guidelines for Marine Protected Areas. Gland, Switzerland, and Cambridge, UK: IUCN, 1999.

By: Anupam Srivastava , Sr.AO

UN Sustainable Development Goal 14: Life below Water

This goal aims to conserve and sustainably use the seas and marine resources. It covers:

- **Achieving the Aichi target to, by 2020, cover 10 per cent of marine waters through protected areas or other effective conservation measures;**
- **ending overfishing, illegal, unreported and unregulated fishing and destructive fishing practices by 2020;**
- **prohibiting certain forms of fishing subsidies by 2020; and**
- **allowing access to marine resources and markets for small-scale, artisanal fishers.**

In 2015, the United Nations (UN) adopted Sustainable Development Goals, setting targets related to "Life below Water" (see Box 1). The European Union (EU) committed to meeting these goals in its seas.

The EU's seas are vast (the term "seas" is used in this report to cover both the Atlantic Ocean and other seas). They contain a wealth of habitats and species and are economically, socially and environmentally important for the EU as shown in Figure 1.

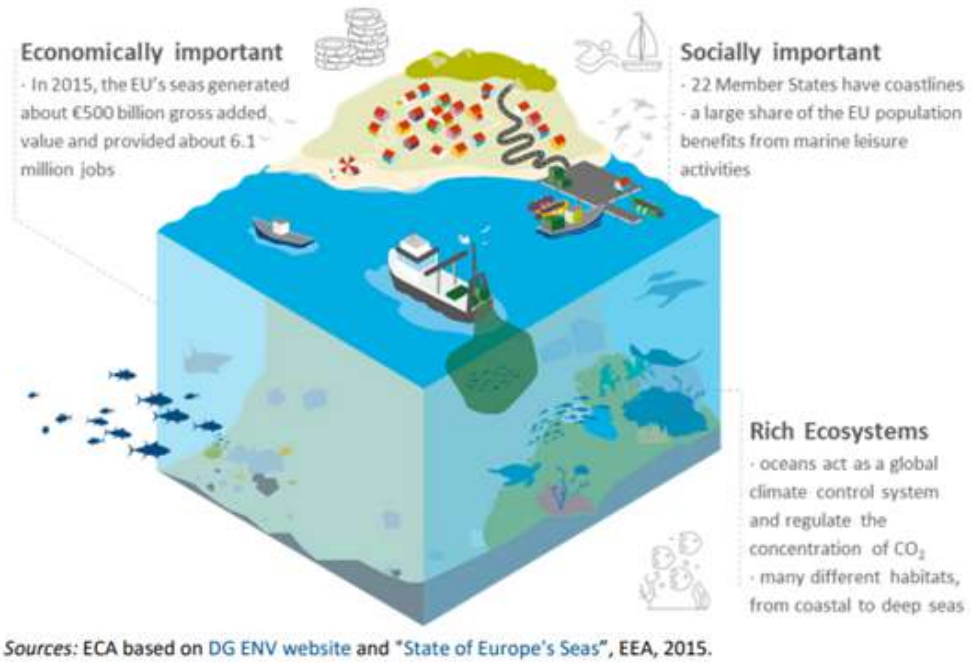


Figure 1: Importance of EU's seas

The Treaty on the Functioning of the European Union (TFEU) requires the EU to integrate environmental protection and sustainable development into its policies. In accordance with the TFEU, the EU has exclusive competence over the conservation of marine biological resources through its common fisheries policy (CFP). The Commission and the Member States share responsibility for environmental policies, the most relevant of which for the seas are set out in directives: the Marine Strategy Framework Directive (MSFD) and the Birds and Habitats Directives (BHDs).

The European Environment Agency (EEA) reported in 2015 on the poor state of many marine species and habitats and it concluded that it could not consider Europe's seas as 'healthy' or 'clean'. In 2020, the EEA reported that loss of marine biodiversity in Europe's seas had not been halted, with a high proportion of marine species and habitats assessments showing an unfavourable conservation status or a status that was unknown.

Audit Approach, Scope and Methodology

The year 2020 was a key year for the EU in terms of meeting conservation objectives under the 2011 biodiversity strategy, the CFP and the MSFD and 2021 had the Conference of Parties to the Convention on Biological Diversity. This report was to provide analysis of the results to date on the protection of marine biodiversity, and thus fed into discussion on future options. Audit covered the period from the adoption of the MSFD in 2008 to 1 March 2020 focusing on the Bay of Biscay and the Iberian Coast, Macaronesia and the Western Mediterranean Sea, and visited the Member States with coastlines on these sea areas – Spain, France, Italy and Portugal to look at the EU policy and spending framework and how it addressed the main pressures on marine biodiversity and habitats, focusing on pressure from commercial fishing and:

- examined the Commission's proposals, guidelines and relevant reports;
- visited national and regional authorities and representatives from the fishing sector and environmental organisations in Spain, France, Italy and Portugal;
- reviewed EU funding for projects to protect the marine environment and examined such projects and 21 long established marine protected areas with diverse protection objectives from the selected sea areas;
- consulted an expert panel to use their expertise to analyse links between environmental and fishing policies; and
- reviewed relevant studies and reports, including those by the Scientific, Technical and Economic Committee for Fisheries (STECF) and the European Environmental Agency.

Significant Audit Observations and Conclusion

(a) EU protection rules have not led to the recovery of significant ecosystems and habitats. The network of marine protected areas was not representative of the EU's diverse seas and sometimes provided little protection. In practice, the provisions to coordinate fisheries policy with environmental policy had not worked as intended, and the species and habitats protected by birds and habitats directives were based on outdated threat assessments.

(b) In the Atlantic, where fisheries management was mostly linked to limits on allowable catches, there was measurable improvement. The majority of fish stocks were fished sustainably. However many stocks were still overfished.

(c) In the Mediterranean, where fisheries management is mostly linked to limits on fishing effort (and not catches), fishing rates were at twice sustainable levels.

(d) The Member States used six per cent of their funding through the European Maritime and Fisheries Fund on measures directly related to conservation measures, and a further eight per cent on measures indirectly related to conservation measures; and we saw good examples of projects funded with LIFE (2) and Interreg (3) .

Overall audit found that, while a framework was in place to protect the marine environment, the EU's actions had not restored seas to good environmental status, nor fishing to sustainable levels in all seas: this assessment was supported by a report by the European Environment Agency, published as audit was concluding its work, which identified that "Marine biodiversity remains under threat in Europe's seas. A high proportion of marine species and habitats' assessments continue to show an 'unfavourable conservation status' or a status that is 'unknown'.

Audit observed that while EU action had resulted in measurable progress in the Atlantic, the Mediterranean remained significantly overfished; and a small share of the European Maritime and Fisheries Fund was used to support marine conservation.

Recommendations:

Based on above findings, recommendations made were aimed at:
(1) identifying the regulatory and administrative changes necessary to protect sensitive species and habitats;
(2) improving protection measures in the Mediterranean; and
(3) increasing the potential of EU funding.

Bibliography:

(1)https://www.eca.europa.eu/lists/ecadocuments/sr20_26/sr_marine_environment_en.pdf
(2) LIFE: is the EU's funding instrument for the environment and climate action since 1992
(3) Interreg: This set of programmes is funded by the European Regional Development fund and supports cooperation across borders through project financing. It aims to jointly tackle common challenges and find shared solutions in various fields, including the environment.

Innovation and Empowerment in Blue Economy – From Underrated Ecosystem to Sustainable Industry

By: Dr. Gulshan Sharma, Research Associate

Introduction

The concept of the Blue Economy has gained significant attention globally as nations recognise the untapped potential of their marine resources. India, with its vast coastline and rich maritime heritage, stands at the cusp of a transformation that could turn its Blue Economy into a thriving, sustainable industry (Choudhary Poonam, 2021). This article delves into the significance of innovation and empowerment in India's Blue Economy, shedding light on its transition from an underrated ecosystem to a source of sustainable economic growth and development (Chen 2018).

The Blue Economy in India

India's Blue Economy encompasses a wide range of activities, from fisheries, aquaculture, and shipbuilding to tourism, shipping, and renewable energy. With a coastline spanning over 7,500 kilometres, the country has the potential to harness its abundant marine resources effectively. Despite this potential, the Blue Economy sector has remained largely underutilised and underdeveloped (Negi 2013).

Innovation in Blue Economy

Innovation is the cornerstone of transforming the Blue Economy in India. By leveraging technology and sustainable practices, the nation can harness the full potential of its maritime resources. Several key areas as shown in Table 1 and Figure 1 where innovation plays a vital role are:

Industry	Innovation for Sustainable Development	Benefits
Sustainable Fisheries	• Real-time tracking using satellite technology • Eco-friendly fishing gear • Responsible fishing practices	• Conserve marine ecosystems • Support the livelihoods of fishermen (Chen 2018).
Aquaculture	• Recirculating Aquaculture Systems (RAS) • Selective breeding	• Increase fish production • Minimise environmental impacts (Mayank Aggarwal 2021).
Renewable Energy	• Offshore wind farms • Marine energy technologies	• Contribute to India's energy security • Reduce greenhouse gas emissions • Create jobs (Mayank Aggarwal 2021).
Shipbuilding and Ports	• Smart ports with advanced logistics and automation	• Revolutionise the shipping industry • Make it more efficient and sustainable • Reduce environmental impacts • Create jobs (Sayad 2023).

Table 1: Sustainable Development of Ocean Resources

Empowerment in Blue Economy:

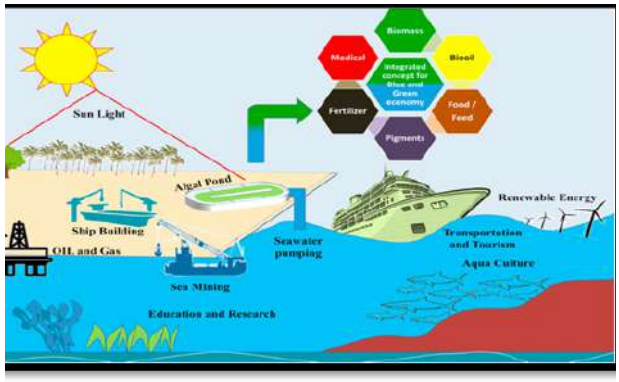


Figure 1: Ocean Resources and Sustainable Development
Image Source(Choudhary Poonam, 2021)

Empowering local communities, particularly coastal communities and fishermen, is equally crucial for the sustainable development of the Blue Economy in India. By providing training, access to technology, and ownership of marine resources, empowerment can lead to social and economic upliftment (Sayad 2023):

1. **Skill Development:** Training and skill development programmes empower fishermen to adopt sustainable practices, enhancing their income and preserving the marine ecosystem. Initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY) in India aim to provide skill development and modern infrastructure to the fishing industry (Ministry of Fisheries, Animal Husbandry and Dairying, 2023).

2. **Community Ownership:** Encouraging community-based resource management allows local communities to have a say in the sustainable use of marine resources, reducing over-exploitation and fostering a sense of responsibility (Choudhary Poonam, 2021).

3. **Women's Participation:** Women play a significant role in the Blue Economy, often engaged in activities such as fish processing and trading. Empowering women by providing training and access to credit can lead to more inclusive and equitable growth in the sector (Sayad 2023).

4. **Legal Frameworks:** Strengthening legal frameworks to protect the rights of coastal communities and traditional fishermen is crucial. It ensures that they are not marginalised in the face of industrialisation and commercialisation of the Blue Economy (Negi 2013).

Sustainable Industry Transition

The Blue Economy in India can be a sustainable industry, requiring a balance of innovation and empowerment. Innovation optimises resource utilisation and minimises environmental impacts, while empowerment ensures equitable distribution of benefits, particularly to marginalised coastal communities, promoting economic prosperity and ecological integrity (Choudhary Poonam, 2021).

Conclusion

India's Blue Economy, often underestimated, holds immense potential for sustainable growth and development. By fostering innovation and empowering local communities, India can tap into the wealth of its marine resources while preserving its natural heritage. The transition from an underrated ecosystem to a sustainable industry will not only bolster the economy but also ensure a brighter, more sustainable future for coastal communities and the environment as a whole.

Bibliography

Chen, Q., Shen, W., & Yu, B. "Assessing the Vulnerability of Marine Fisheries in China: Towards an Inter-Provincial Perspective. ." Sustainability 101, no. 11 (November 2018): 4302.

Choudhary Poonam. "Empowering blue economy: From underrated ecosystem to sustainable industry." Journal of Environmental Management (Elsevier), april 2021.

Mayank Aggarwal. India's tidal power potential hampered by high costs and environmental risks. Mongabay-India, August 20, 2021.

Ministry of Fisheries, Animal Husbandry and Dairying. "Allocation in Budget FY 2023-24 for Department of Fisheries marks an overall increase of 38.45% over the Budget of FY 2022-23." 2023.

Negi, R. K., Mamgain, S. "Species Diversity, Abundance and Distribution of Fish Community and Conservation Status of Tons River of Uttarakhand State, India." Journal of Fisheries and Aquatic Science, 8, no. 5 (May 2013): 617–626.

Sayad, Younes Oulad. "Mapping Potential Fishing Zones Using Remote Sensing Data and GIS: A Case Study of Moroccan Waters." Multimedia Research, 6, no. 2 (June 2023): 1–13.

By: Dr. Mahesh Kumar Saini, Research Associate

Introduction

Dugongs, marine mammals resembling a dolphin and walrus, have rounded bodies, flippers, and fluke-shaped tails, but lack a dorsal fin. They surface carefully, swim slowly, and have a walrus head. Growing up to 3 meters, they are the only plant-eating mammals in the ocean.

Source: (ferrebeekeepe, 2011)

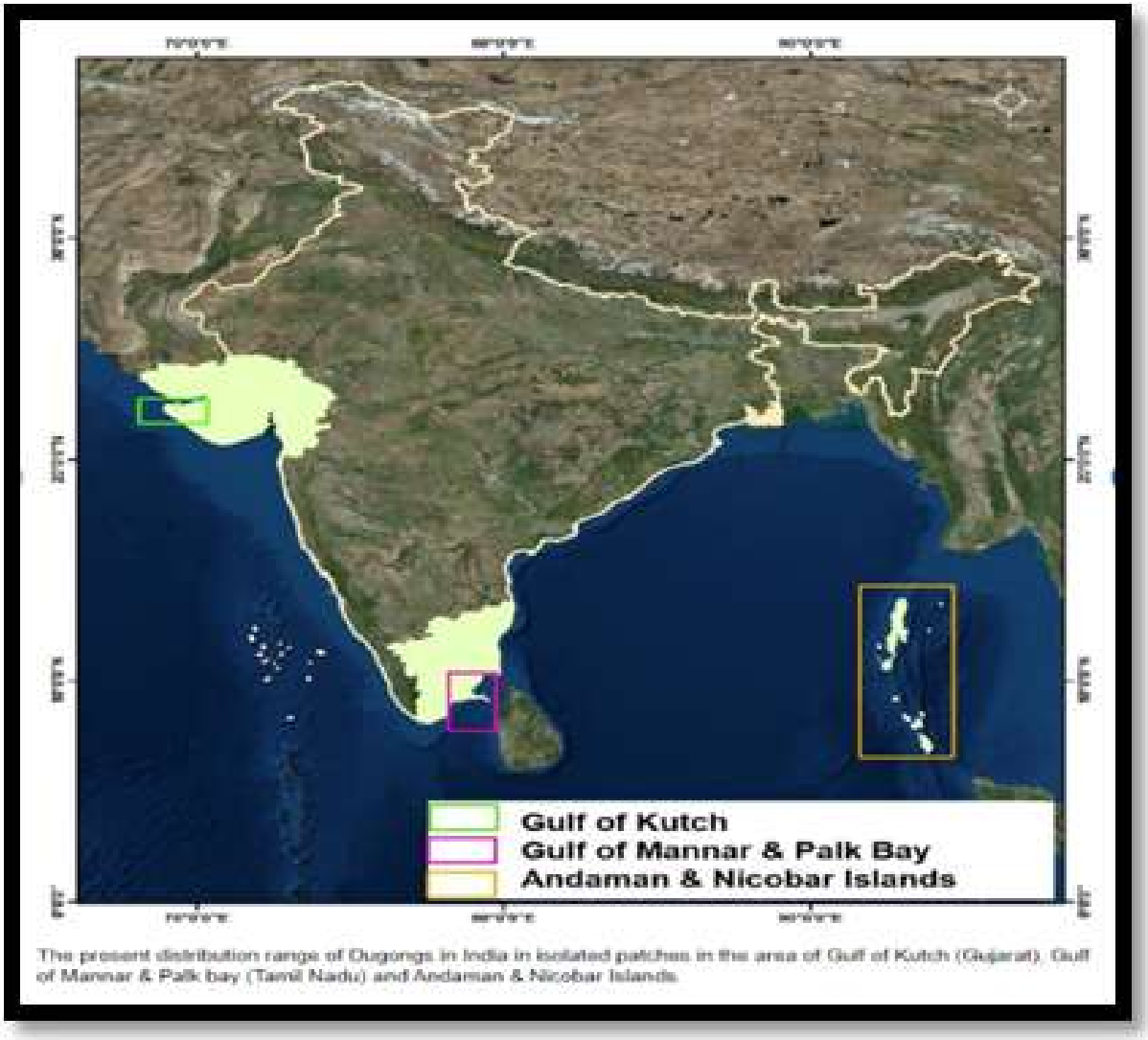
Domain:	Eukaryota
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Sirenia
Family:	Dugongidae
Subfamily:	Dugonginae
Genus:	*Dugong* Lacépède
Species:	*D. dugon*

Ecological Importance

Dugongs are aquatic herbivores, primarily eats seagrass, which is easy to chew, high in nutrients, and low in fibre. They alternate between different seagrass species and contribute to the upkeep of seagrass meadows. Dugongs inhabit coastal waters, particularly those with shallow bays, mangrove channels, and dense seagrass beds. They spend most of their life within 1.5 metres of the ocean's surface (Chilvers 2004).

International and National Status of Dugong

Dugongs, a vulnerable species listed by the International Union for Conservation of Nature (IUCN), inhabit tropical and subtropical coastal waters in thirty seven (37) countries and territories. In India, they are protected under Schedule I of the Wild Life (Protection) Act, 1972. A 2013 survey report found only two hundred (200) dugongs in the Gulf of Mannar, Andaman, Nicobar Islands, and Gulf of Kutch (WII 2016).



Present Distribution Range of Dugongs in India Source: (K.Sivakumar, 2019)

Dugong sites in India

Dugongs are found in four main sites in India: the Gulf of Mannar and Palk Bay, the Gulf of Kutch, and the Andaman and Nicobar Islands. The Gulf of Mannar and Palk Bay has the largest population of dugongs, with around two hundred individuals (WII 2016). The Tamil Nadu Government established India's first Dugong Conservation Reserve in 2023, covering 448 km2. The reserve aims to protect dugongs from threats like habitat loss and poaching. Visitors can visit the sites by joining a boat tour or staying at a coastal resort offering snorkelling and diving excursions. Respecting their habitat is crucial (Sivakumar, K. and Nair, A., 2013).

Steps Taken for Conservation

In February 2020, India served as the host for the 13th Conference of Parties (CoP) of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), an international environmental treaty operating under the auspices of the United Nations Environment Programme (UNEP) (UN environment 2017).

The Government of India has been a signatory to the CMS since 1983, and it has entered into non-legally binding Memorandums of Understanding (MoU) with the CMS on several occasions to address the conservation and management of various species, including Siberian Dugongs (2008) (UNEP 2014).

To further the cause of dugong conservation, the Ministry of Environment, Forests, and Climate Change established a 'Task Force for Conservation of Dugongs.' This task force is responsible for investigating issues related to dugong conservation and ensuring the effective implementation of the 'UNEP/CMS Dugong MoU' within India's borders (CMS 2019).

Conclusion

Industrial pollution and boat traffic in India pose significant threats to dugongs, with the least found in the coastal region. To protect these delicate animals, a dugong reserve should be established, focusing on habitat loss and boat collisions. Tourists can visit dugong sites, and thorough mapping of seagrass is needed. State forest departments should inform the public and involve local stakeholders in conservation efforts.

Bibliography

Chilvers, B.L., Delean, S., Gales, N.J., Holley, D.K., Lawler, I.R., Marsh, H. and Preen, A.R.,. "Diving behaviour of dugongs, Dugong dugon." Journal of Experimental Marine Biology and Ecology, 2004: 203-224.

CMS. India Signs Dugong MoU. October 5, 2019. https://www.cms.int/dugong/en/news/india-signs-dugong-mou (accessed October 30, 2023).

Sivakumar, K. and Nair, A.,. Dugong Distribution, Habitat and Risks Due to Fisheries and Other Anthropogenic Activities in India. Wildlife Institute of India–Technical Report, NO: WII, 2013.

Sivkumar,K. (2019). Dugong Scholarship Program in India: a positive incentivization of wildlife conservation values in fisher communities. Research Gate.net. Retrieved from https://www.researchgate.net/figure/The-present-distribution-range-of-Dugongs-in-India-in-isolated-patches-in-the-area-of_fig1_332344924

UN environment. Convention on Migratory Species. Draft Report, Bonn Germany: CMS, 2017.

UNEP. A Natural Affiliation. 11th MEETING OF THE CONFERENCE OF THE PARTIES, no: CMS, 2014.

WII. Dugong. June 20, 2016. https://wii.gov.in/campa_Dugong (accessed October 30, 2023).

By: Akash Sharma, Research Associate

Image Source: (The Indian Express, 2023)

"**Maritime Security and the Blue Economy: Two Sides of the Same Coin**" emphasise that without a sufficient degree of security, ocean resources like tourism, wind farms, fishing or offshore oil platforms cannot be developed (European Union 2018). The World Bank defines the Blue Economy as the "sustainable use of ocean resources for economic growth, improved livelihoods and jobs while preserving the health of ocean ecosystem". The activities commonly understood to represent the Blue Economy include maritime shipping, fishing, aquaculture, coastal tourism, renewable energy, water desalination, undersea cabling, seabed extractive industries and deep-sea mining, marine genetic resources, and biotechnology (McBain 2023). Goal 14 of the Sustainable Development Goals (SDGs) is to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" (UN SDGs, 2023), and specifically target 14.c "Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want", shows its alignment with the Blue Economy and Maritime Security.

Figure 1: Maritime Security In The Indian Ocean (Stable Seas 2021)

The Indian Ocean is a huge marine zone encompassing coastal states ranging from the southern tip of South Africa to the west coast of Australia as shown in Figure 1. Thirty-six nations have access to the Indian Ocean, with significant variances in their cultural, social, and economic characteristics.

As the world's third biggest ocean, the region is home to around one-third of the world's inhabitants (Upadhyaya 2014). India has taken a pivotal role in the association in tandem with the strategic vision for engagements in the Indian Ocean region (IOR) as defined by SAGAR – Security and Growth for all in the Region as the Indian Ocean's sea lanes are among the most strategic significant in the world, with more than 80 per cent of the world's seaborne traffic in oil transiting via the Indian Ocean and its critical chokepoints. To curb this the Information Fusion Centre – Indian Ocean Region (IFC-IOR) is a regional maritime security centre that was established by the Indian Navy in the year 2018, the centre works towards enhancing maritime security and safety in the Indian Ocean.

Potential challenges

Challenges like maritime terrorism, piracy, and armed robbery, as shown in Figure 2, human and contraband trafficking, Illegal, Unregulated and Unreported (IUU) fishing, marine pollution, gun running, and poaching require situational awareness of maritime activities (IFC-IOR 2022). These activities can disrupt marine ecosystems and exacerbate the effects of Climate Change (European Commission, 2023).

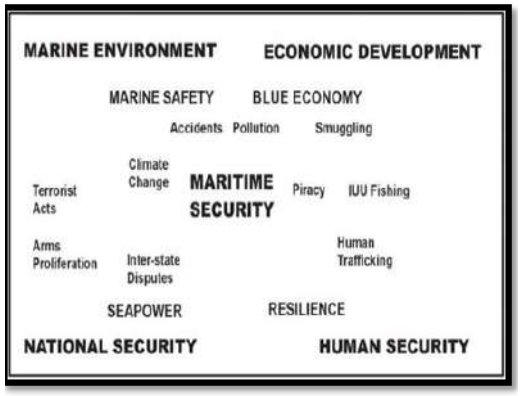


Figure 2: Challenges and Solutions for Maritime Security (Bueger 2015)

Policy initiatives

The Ministry of Earth Sciences (MoES) has rolled out the draft National Policy for India's Blue Economy 2021. The policy document aims to enhance the contribution of the Blue Economy to India's Gross Domestic Product (GDP), improve the lives of coastal communities, preserve marine biodiversity, and maintain the national security of marine areas and resources (Ministry of Fisheries, Animal Husbandry & Dairying 2022) and Indo-Pacific Oceans' Initiative (IPOI) proposed at the 14th East Asia Summit in Bangkok in November 2019, is considered a landmark intervention in propelling robust international cooperation with a focus on seven pillars of maritime security including maritime ecology; maritime resources; capacity building and resource sharing; disaster risk reduction and management; science, technology and academic cooperation; and trade connectivity and maritime transport (Debasis Bhattacharya 2021).

Recently, Maritime Amrit Kaal Vision 2047, launched during the Global Maritime Summit 2023, unveiled the blueprint for the Indian maritime Blue Economy, and discussed key issues of the maritime sector including ports of the future, decarbonisation, coastal shipping and inland water transportation, shipbuilding, repair and recycling, finance, insurance and arbitration, maritime clusters; innovation and technology, maritime safety and security; and maritime tourism (Prime Minister's Office 2023).

Pointers for Audit

1. Projects worth more than ₹ 23,000 crore have been announced.
2. The Centrally Sponsored Scheme (CSS) – 'Blue Revolution: Integrated Development and Management of Fisheries' was launched in 2015-16 with an outlay of ₹ 3000 crore for five years.
3. Pradhan Mantri Matsya Sampada Yojana (PMMSY) of 2020 aims to bring about a Blue Revolution through sustainable and responsible development of the fisheries sector in the country. The government invested ₹ 20,050 crore in this initiative.

Conclusion

The interdependency of maritime and Blue Economy growth is not only beneficial for economic development but also plays a vital role in protecting marine biodiversity and combating Climate Change in the Indian Ocean region.

Bibliography

Bueger, Christian. 2015. "What is maritime security?" Marine Policy 53: 159-164. Accessed October 31, 2023. doi:https://doi.org/10.1016/j.marpol.2014.12.005.

Debasis Bhattacharya. 2021. India's focus on enhancing maritime security as the UNSC president: Leadership envisioning a global roadmap. Observer Research Foundation. Aug 26. Accessed October 31, 2023. https://www.orfonline.org/expert-speak/indias-focus-on-enhancing-maritime-security-as-the-unsc-president/.

Eureopean Commission. 2023. EU Maritime Security Strategy and its Action Plan "An enhanced EU Maritime Security Strategy for evolving maritime threats". JOINT COMMUNICATION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, Brussels: Oceans and fisheries. Accessed October 31, 2023. https://oceans-and-fisheries.ec.europa.eu/system/files/2023-03/join-2023-8_en.pdf.

European Union. 2018. "The Diplomatic Service of the European Union." European Union External Action. 12 06. Accessed October 31, 2023. https://www.eeas.europa.eu/node/54941_en#:~:text=It%20was%20pointed%20out%20that%20maritime%20security%20and,not%20threatened%20by%20piracy%20or%20other%20criminal%20activity.

IFC-IOR. 2022. annual report. Annual report, Indian Navy, Gurugram: Indian Navy, India, 1-72. Accessed October 31, 2023. https://www.indiannavy.nic.in/ifc-ior/static/data/reports/annual/3.%20IFC-IOR%20Annual%20Report%202022.pdf.

McBain, Darian. 2023. "What is the blue economy?" The London School of economics and political sciences (grantham reserach institute of climate change and the enviornment). May 16. Accessed October 31, 2023. https://www.lse.ac.uk/granthaminstitute/explainers/what-is-the-role-of-the-blue-economy-in-a-sustainable-future/.

Ministry of External Affairs, GOI. n.d. foreign relations. Accessed October30,2023.https://www.mea.gov.in/Portal/ForeignRelation/IORA_new.pdf#:~:text=Indian%20Ocean%20Rim%20Association%20%28IORA%29%20%20formerly%20known,development%20and%20balanced%20economic%20growth%20of%20its%20members.

Ministry of Fisheries, Animal Husbandry & Dairying. 2022. PIB, India. March 25. Accessed October 31, 2023. https://pib.gov.in/PressReleasePage.aspx?PRID=1809728.

Prime Minister's Office. 2023. PIB, India. 10 17. Accessed October 31, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1968331.

Stable Seas. 2021. Stable Seas. Mar 5. Accessed October 31, 2023. https://www.stableseas.org/post/challenges-and-solutions-for-maritime-security-in-the-indian-ocean.

The Indian Express. 2023. 20th ASEAN-India summit in Jakarta: 2 sides to join forces on blue economy, maritime security. September 8. https://indianexpress.com/article/india/20th-asean-india-summit-in-jakarta-2-sides-to-join-forces-on-blue-economy-maritime-security-8929679/.

UN SDGs. 2023. The Sustainable Development Goals Report 2023: Special Edition. July 10. Accessed Ovtober 31, 2023. https://unstats.un.org/sdgs/report/2023/.

Upadhyaya, Shishir. 2014. "Maritime security cooperation in the Indian Ocean Region: The role of the Indian Navy." Australian Journal of Maritime & Ocean Affairs 6 (4): 173–190. Accessed October 30, 2023. doi: https://doi.org/10.1080/18366503.2014.920945.

By: Maneesh Mangal, AAO

Introduction

Himachal Pradesh is the largest State in the Indian Himalayan Region (Figure 1) with diverse biodiversity and climate comprising an area of 55,673 sq.kilometres in the North-Western Himalaya with beautiful landscapes, lush green forests, bubbling streams, emerald meadows, enchanting lakes, eternal snows, ethnic communities and colourful people (Govt. of India, 2011). It is bounded by Tibet in the east, Jammu and Kashmir in the north, and Uttaranchal in the southeast. Haryana in the south and Punjab in the west.

Figure 1: Map of Himachal Pradesh Image Source: (Maps of India), 2023)

Environment:

- **Forest and Climate:** The total geographical area is 1.7 per cent of the country's area and 66.52 per cent is under forests. Out of the total forest area, 26.37 per cent area is under tree cover. It supports 30 Wildlife Sanctuaries; two National Parks (Pin Valley National Park and Great Himalayan National Park) and three conservation reserves. The vegetation varies from dry scrub forests at lower altitudes to alpine pastures at higher altitudes. In between these two extremes, distinct vegetation zones of Mixed Deciduous Forests, Bamboo, Chir Pine, Oak, Deodar, Kail, Fir and Spruce are found (Forest Survey of India 2019).

- **Mineral Resources**: Himachal Pradesh has no major metallic mineral deposits but abundant non-metallic minerals. Himachal is the only State with a working rock salt mine. Among the 37 reported minerals, only a few like limestone, baryte, shale, rock salt, silica sand, magnesite, gypsum, quartzite, slate, and building stone have practical significance (Arun K. Sharma n.d.).

- **Biodiversity**: Himachal Pradesh hosts 3,256 floral species, comprising ferns, higher plants, fungi, mosses, and lichens, out of the 47,000 species found in India. Himachal Pradesh also has a rich and unique fauna, with 5,721 species (out of a total of 89,451 species found in India). It boasts the world's largest population of Chir pheasants. The State is endowed with a variety of Medicinal and Aromatic Plants (MAPs), and approximately 187 species. According to the Himachal Pradesh Forest Department, 57 species of MAPs have gone threatened due to unscientific extraction. In addition, the Himachal Pradesh State Biodiversity Board (HPSBB) has also released a list of 16 threatened faunal species. A number of floral and faunal species have been included in the International Union for Conservation of Nature (IUCN) Red List (Pandey 2021).

- **Fisheries**: Himachal Pradesh's picturesque beauty is complemented by its fast-flowing rivers: Chenab, Ravi, Beas, Sutlej and Yamuna flowing 878 km and covering 47,271 sq km catchment area (Himachal Study 2020). In 2019, the State produced 13,401.68 metric tonnes of fish worth ₹ 171.57 crore, providing employment to 6,098 fishermen (Department of Information and Public Relations 2019). In 2022, Himachal Pradesh produced 16,000 metric tonnes of fish, which was an overall increase of volume of about eight thousand metric tonnes from fiscal year 2009 and 20 per cent from 2019 (Keelery 2023).

- **Wetlands**: The State has three designated Ramsar wetlands of International importance namely Renuka (Sirmour), Chandertal (Lahaul and Spiti) and Pong Dam (Kangra) wetlands. Besides these, the State has two wetlands of National importance i.e., Khajjiar (Chamba) and Rewalsar (Mandi) wetlands (HPSWA 2018).

Pollution

Established in 1974 under environmental acts, the Himachal Pradesh State Pollution Control Board oversees water, air, and environmental regulation. Its goal is to maintain environmental quality, prevent hazards to humans, and protect flora and fauna.

- **Air Pollution:** Major sources of air pollution in Himachal Pradesh include industries (like mining and cement) and the vehicular sector. However, growth of population and developmental activities are the driving forces behind the deteriorated air quality of the State (HPSPCB 2021).
- **Water Pollution:** The Central Pollution Control Board under the National Water Quality Monitoring Programme (NWMP/ MINARS) is sponsoring the water quality monitoring of major rivers of the State. The monitoring under the centrally sponsored programme has been carried out at 213 locations on a monthly basis, besides, the water quality at 131 locations was also monitored by the State Board on a quarterly basis under the State Water Quality Monitoring (SWQM) Programme. The key challenge to water quality management in the State are discharge of untreated or partially treated civic wastes/effluent mainly from urban settlements, industrial establishments and agricultural runoffs. The State not only needs to bridge the gap in the existing treatment capacity and optimal connectivity but also keep pace with the growing rate of urbanisation and population (HPSPCB 2021).

- **Waste Management:** Himachal Pradesh encompasses 61 Urban Local Bodies for solid waste management with an overall generation of 346 tonnes of municipal solid waste per day (TPD) in 2020-21. Out of this, 332 TPD solid waste is collected. Approximately 66 per cent i.e., 221 TPD is treated and the rest 111 TPD is landfilled (Central Pollution Control Board 2022).

Risk of Natural Disasters

Earthquakes:-Himachal Pradesh faces a range of natural and manmade hazards, making it susceptible to various risks. These include earthquakes, landslides, flash floods, snowstorms, avalanches, droughts, dam failures, domestic and wild fires, accidents (road, rail, air), stampedes, boat capsizing, biological threats, and industrial hazards involving chemicals. Among these, the most significant threat to the state is the earthquake hazard.

The historical seismic activity in Himachal Pradesh indicates that the region has experienced over 80 earthquakes with a magnitude of 4 or higher on the Richter Scale. According to the seismic zoning map provided by the Bureau of Indian Standards (BIS), certain districts in the state face a particularly high risk. Specifically, Chamba, Hamirpur, Kangra, Kullu, and Mandi districts have 53% to 98.6% of their area prone to the severest design intensity of MSK IX or higher, with the remaining areas in these districts susceptible to the next severe intensity, MSK VIII.

In Bilaspur and Una districts, 25.3% and 37.0% of their respective areas are exposed to MSK IX intensity, while the remaining areas face MSK VIII intensity. The other districts in the state also face a significant risk, primarily at MSK VIII intensity.

Landslides: - Himachal Pradesh is consistently confronted with the challenge of landslides, particularly during the monsoon season and high-intensity earthquakes. The hills and mountains in the region are susceptible to these events, and the geologically young and less stable steep slopes in various Himalayan ranges have become increasingly vulnerable in the past decade.

This heightened risk is attributed to human activities such as deforestation, road construction, terracing, and changes in agricultural practices that demand more intensive watering.

Floods:- The Shiwalik and lower to mid Himalayan ranges experience significant flooding during the monsoon seasons, primarily attributed to high rainfall. In the upper reaches of the Beas and Satluj valleys, flash floods and bank erosion pose major challenges due to steep river slopes and increased water flow resulting from heavy precipitation. Instances of flash floods are often triggered by cloudbursts, glacial lake outbursts, and temporary blockages in river channels. (HPSDMA, 2020)

Performance under the SDGs

As per SDG India Index 2020, Himachal Pradesh ranks 2nd (Figure 2) with a composite score of 74 which is above the national average. The Highest score achieved is 100 in SDG 7 (Affordable and Clean Energy). The State has a poor performance in SDG 2 (Zero Hunger). SDG 14 (Life below Water) score is not available for Himachal Pradesh (Niti Aayog 2020).

Figure 2: SDG Performance for the State of Himachal Pradesh

Pointers for Audit

Going by the above discussion, auditing planning can include considerations of biodiversity conservation, wetlands management, inland fisheries, air pollution, water pollution, waste management and disaster action plan. Further, the States' location in the geologically sensitive and seismically active area, in addition to its vulnerability to flooding need to be taken into consideration while planning for audit relating to environment issues. However, special emphasise should be given while auditing Himachal Pradesh State Disaster Management Authority. Himachal Pradesh has a State Disaster Management Plan 2017 in accordance with the Disaster Management Act, 2005. While auditing, special focus on the following audit points could be considered keeping in view the recent events:

- Fund allocated to state emergency operations centre and utilisation of funds for designated purpose.
- Deficiencies in processing disaster alerts and warnings from nodal agencies to communicate the same to all designated authorities.
- Deficiencies in coordination among departments and agencies performing various primary and secondary Emergency Support Functions.
- Any shortfall in issuing disaster/incident specific information and instructions specific to all concerned shareholders.
- Actual physical availability of resources as envisaged and allocated by authority for emergency response system.

Bibliography

Central Pollution Control Board. 2022. Annual Report 2020-21 on Implementation of Solid Waste Management Rules, 2016. New Delhi: Central Pollution Control Board http://www.ud.hp.gov.in/sites/default/files/documents/H.P.%20SWM_Strategy_Final_20190601.pdf.

Niti Aayog. 2020. SDG India Index & Dashbord . https://sdgindiaindex.niti.gov.in/#/state-compare?goal=AllGoal&area=IND002&timePeriod=2020.

Arun K. Sharma, Rajneesh Sharma,Dr. H. R. Dandi. n.d. Mineral Resources of Himachal Pradesh. https://emerginghimachal.hp.gov.in/miningstone/survay_docs/Mineral_Resources_of_Himachal_Pradesh.pdf.

Department of Information & Public Relations, Himachal Pradesh. 2019. "Blue Revolution."http://himachalpr.gov.in/.August04. http://himachalpr.gov.in/PressReleaseByYear.aspx?Language=1&ID=14175&Type=2&Date=04/08/2019.

Forest Survey of India. 2019. India State of Forest Report 2019. Dehradun: Forest Survey of India. https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-himachal-pradesh.pdf.

Govt of India 2011 Himachal Pradesh. https://knowindia.india.gov.in/states-uts/Himachal-Pradesh.php#:~:text=Himachal%20Pradesh%20came%20into%20being,position%20remained%20unchanged%20till%201966.

Himachal Study. 2020. Rivers-of-Himachal-Pradesh. November 8. https://himachalstudy.com/rivers-of-Himachal-pradesh/28/.

HPSDMA. 2020. Hazard profile . December 4. https://hpsdma.nic.in/index1.aspx?lsid=70&lev=2&lid=62&langid=1.

HPSPCB. 2021. Annual Report 2020-21. New Shimla: H.P. State Pollution Control Board.

HPSWA. 2018. Himachal Pradesh State Wetlands Authority. February. https://himcoste.hp.gov.in/Wetland%20Authority/Wetland_pdf/World%20Wetland%20day%202018%20report.pdf.

Keelery, Sandhya. 2023. Fish production volume across Himachal Pradesh. August 24. https://www.statista.com/statistics/735869/fish-production-volume-himachal-pradesh-india/#:~:text=The%20north%20Indian%20state%20of,tons%20in%20fiscal%20year%202009.

Pandey, Rita. 2021. Biodiversity Strategy and Action Plan (BSAP) For Himachal Pradesh. New Delhi: National Institute of Public Finance and Policy.

Cruise Tourism and Need for Sustainability in the Marine Tourism Sector

By: Rohan Sharma, AAO

Figure 1: Cruise
Source: (Ministry of Ports, Shipping and Waterways 2021)

Introduction

In the context of coastal and marine tourism, the initial tourist preference for coastal areas, islands, and reefs primarily revolved around leisurely activities like sunbathing and swimming. This preference prompted significant investments in tourism infrastructure along the coastline. However, contemporary tourists, influenced by post-modern trends, now seek more interactive and educational experiences related to the marine environment. Consequently, they actively participate in a range of activities such as cruising, snorkelling, surfing, scuba diving, jet skiing, and sailing.

Cruise tourism is a comprehensive and inclusive sector, facilitating the movement of tourists and travellers from one location to another, even to geographically remote destinations that may pose accessibility challenges by land. This is achieved in a secure, hassle-free, and comfortable environment for the entire duration of the journey (Ministry of Tourism 2023).

Global economies have adopted a systematic approach to stimulate the growth of the cruise industry. In Asia, the majority of cruises have a shorter average duration, typically ranging from two to five days. This variance in cruise length in Asia may be attributed to distinct vacation customs, in contrast to the 7 to 10 days cruises commonly found in Europe and the Caribbean regions (Ministry of Ports, Shipping and Waterways 2021).

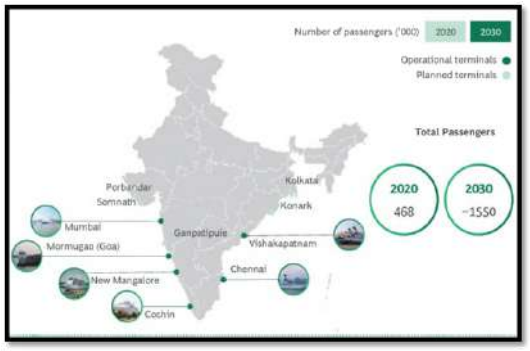


Figure 2: Current and Potential Cruise Terminals
Source: (Ministry of Ports, Shipping and Waterways 2021)

According to Maritime India Vision 2030, the potential demand for cruise tourism in India is likely to increase by eight times over the next decade to reach 15 lakh passengers by 2030. Figure 2 below shows the current and Potential Cruise terminals in India.

Obstacles in the Marine Tourism Sector

Expanding marine tourism yields economic advantages through job creation, livelihood enhancement, support for fishing activities, and improved economic prosperity. Nevertheless, it also gives rise to environmental challenges, including overcrowding, environmental degradation, waste generation, increased strain on natural resources, and adverse effects on marine ecosystems (Asian Development Bank 2020) .

The primary obstacles facing marine tourism revolve around the preservation of sea and marine resources, which includes the conservation of marine ecosystems, the mitigation of marine pollution, and the sustainable utilisation of marine resources. Preserving coastal biodiversity, natural assets, and the coastal and marine environment is vital for ensuring enduring sustainability. This form of tourism can have detrimental effects on the environment due to irresponsible activities associated with nature (Asian Development Bank 2020).

Startling data indicates that cruise ships and maritime vessels are responsible for approximately three per cent of the world's annual greenhouse gas emissions, diminishing the picturesque landscapes they navigate. Currently, a minuscule 0.1 per cent of ships globally utilise zero-emission technology, underscoring the substantial progress required to make the cruise industry more environmentally friendly (Ministry of Tourism 2020).

Way Forward

Coastal and marine tourism relies significantly on the well-being of coastal and marine ecosystems to entice visitors, and it faces notable vulnerability to challenges like Climate Change and the loss of biodiversity. Thus, a robust and thriving ocean serves as the fundamental underpinning for this sector. Guaranteeing the sustained health of the ocean is essential to bolster the local communities and economies that depend on the tourism industry.

To ensure the sustainability of the tourism sector, the following measures can be implemented:

1. Concentrate tourism policies, plans, product development, and marketing efforts on attracting visitors, both domestic and international, who genuinely seek to engage with the communities and destinations they visit, while actively supporting local environment, economy, and community regeneration.
2. Formulate strategies to enhance sustainable and robust funding for conservation and restoration initiatives, including the management and enforcement of Marine Protected Areas. This can be achieved by leveraging user fees, environmental taxes, and the establishment of conservation trust funds, ensuring that conservation funding remains resilient even during declines in visitation.

3. Gather, incorporate, and maintain data on sustainability indicators, including the use of national ocean and tourism accounts. This data can guide local authorities in managing operational externalities and direct appropriate investments toward sustainability requirements.

Bibliography

Asian Development Bank. “MARINE TOURISM FOR SUSTAINABLE DEVELOPMENT IN COX’S BAZAR, BANGLADESH.” June 2020. https://www.adb.org/publications/marine-tourism-sustainable-development-cox-bazar-bangladesh.

Ministry of Ports, Shipping and Waterways. “MIV 2030.” 12 February 2021.https://sagarmala.gov.in/sites/default/files/MIV%202030%20Report.pdf.

Ministry of Tourism. “Draft National Policy for Cruise Tourism.” https://static.pib.gov.in/.June2023. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/jun/doc2023627218001.pdf (accessed October 31, 2023).

Ministry of Tourism. “How a turbo charged cruise industry can become another symbol of bold and self-reliant India.” How a turbo charged cruise industry can become another symbol of bold and self-reliant India, 2020.

Green Hydrogen Policy and Global Efforts to Produce Green Hydrogen as a Clean Source

By: Manoj Kumar, AAO

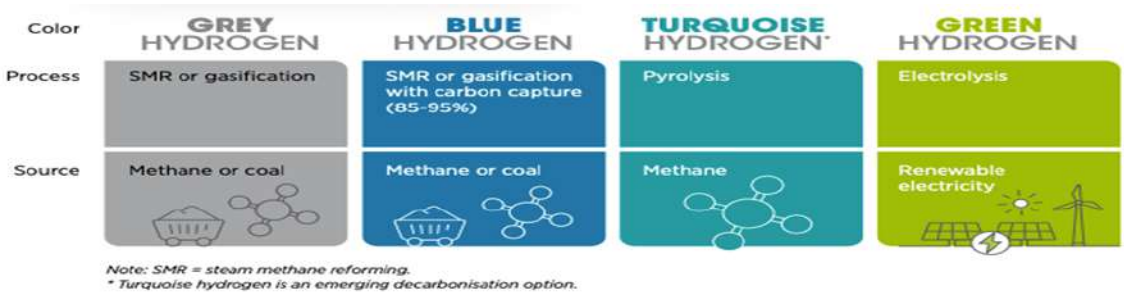
Introduction: The rise of technologies such as solar and wind energy, lithium-ion batteries, and alternative fuels have paved the way for decarbonisation in various end-use sectors. However, there are certain sectors such as industry and heavy transport that are hard to decarbonise using the current low- or zero-carbon technologies. In this scenario, Hydrogen promises to address these challenges and contribute to the decarbonisation of these hard-to-abate sectors.

Image Source: (TERI , 20222)

2. Hydrogen Fundamentals

Hydrogen combustion results exclusively in the emission of water vapour; however, the production process itself may entail a significant carbon footprint. The various types of hydrogen, namely grey, blue, and green, are contingent upon distinct production methods. In some instances, hydrogen may even manifest in unconventional hues such as pink, yellow, or turquoise. Notably, green hydrogen stands out as the sole variant produced in a climate-neutral fashion (World Economic Forum 2021). Based on the sources and processes, hydrogen can be classified into various colours:

Hydrogen's specific energy (i.e., energy content per unit of mass) is higher than most hydrocarbon fuels. But its volumetric energy density is the lowest. That means pressurisation or liquefaction is required for hydrogen to be useful as a fuel. These two properties drive the value as well as the applicability of hydrogen for the various possible end-use cases.



Depending on production methods, hydrogen can be grey, blue or green – and sometimes even pink, yellow or turquoise Image source: International Renewable Energy Agency

Green hydrogen is specifically delineated as hydrogen generated through the electrolysis of water, a process involving renewable electricity to separate hydrogen and oxygen (World Economic Forum 2021). As per Office Memorandum No. 353/35/2022-NT dated 18 August 2023 of the Ministry of New and Renewable Energy (MNRE), National Green Hydrogen Mission, "Green Hydrogen" refers to hydrogen production utilising renewable energy sources, encompassing processes such as electrolysis or conversion through biomass, among other methods (Ministry of New and Renewable Energy 2023). Green hydrogen is generated through the electrolysis of water, employing electricity derived from renewable energy sources. The carbon intensity of the produced hydrogen is contingent upon the carbon neutrality of the electricity source. In essence, the greater the proportion of renewable energy in the electricity fuel mix, the more environmentally sustainable or "greener" the resulting hydrogen becomes (NITI Aayog and RMI Report 2022).

3. Green Hydrogen Mission

In his address to the nation on the occasion of the 75th Independence Day, Prime Minister Shri Narendra Modi declared the initiation of the National Hydrogen Mission, with the objective of positioning India as a central hub for the production and export of green hydrogen.

On 4 January 2023, the Union Cabinet granted approval to the National Green Hydrogen Mission, allocating a financial provision of ₹ 19,744 crore. This includes ₹ 17,490 crore earmarked for the Strategic Interventions for Green Hydrogen Transition (SIGHT) programme, ₹1,466 crore for Pilot Projects, ₹400 crore for Research and Development and ₹ 388 crore designated for other mission components. The MNRE is entrusted with the responsibility of formulating the scheme guidelines for the implementation of the respective components (Ministry of New and Renewable Energy, 2022).

The Mission encompasses several key components, as outlined below:

(i) Facilitating demand creation through exports and domestic utilisation;

(ii) The SIGHT programme, a significant financial initiative with an outlay of ₹17,490 crore. This programme includes two distinct financial incentive mechanisms aimed at supporting the domestic manufacturing of electrolysers and the production of Green Hydrogen;

(iii) Pilot Projects for green steel, mobility, shipping, decentralised energy applications, hydrogen production from biomass, hydrogen storage, etc.;

(iv) Development of Green Hydrogen Hubs;

(v) Support for infrastructure development;

(vi) Establishing a robust framework of regulations and standards;

(vii) Research and Development programme;

(viii) Skill development programme; and

(ix) Public awareness and outreach programme.

The Mission is anticipated to result in the development of a Green Hydrogen production capacity of 5 million Metric Tonnes (MMT) per annum by 2030, contributing to a reduction in dependence on the import of fossil fuels. The achievement of Mission targets is projected to curtail cumulative fossil fuel imports by ₹ 1 lakh crore by 2030. This is poised to catalyse over ₹ 8 lakh crore in total investments and generate over six lakh jobs. The production and utilisation of the targeted quantum of Green Hydrogen are expected to avert nearly 50 MMT per annum of CO2 emissions (Ministry of New and Renewable Energy, 2023).

In pursuit of transforming India into a global hub for the production, utilisation, and export of Green Hydrogen, the Government has undertaken various strategic initiatives, including but not limited to:

• A 25-year waiver of inter-state transmission charges has been accorded to producers of Green Hydrogen and Green Ammonia for projects commissioned prior to 31 December 2030.

• The Electricity (Promoting Renewable Energy through Green Energy Open Access) Rules, 2022, formally announced in June of the same year, have delineated specific provisions aimed at streamlining the facilitation of renewable energy supply through Open Access, particularly for Green Hydrogen production (Ministry of New and Renewable Energy, 2023).

4. India Initiatives in Promoting Green Hydrogen

Presently, the production of Hydrogen in India is significantly constrained, primarily derived from renewable sources within the nation. Various entities have disclosed intentions to establish production facilities for Green Hydrogen and Green Ammonia in India. Nevertheless, these initiatives are currently in their nascent stages of development (Ministry of New and Renewable Energy, 2023).

The MNRE has opted to categorise Green Hydrogen with a well-to-gate emission criterion, encompassing processes such as water treatment, electrolysis, gas purification, as well as the drying and compression of hydrogen. This criterion stipulates that the emissions should not exceed 2 kg of CO2 equivalent per kilogram of H2.

In a noteworthy stride towards advancing the objectives of the National Green Hydrogen Mission, the government has officially released the Green Hydrogen Standard for India. This standard, disseminated by the (MNRE), Government of India, delineates the emission thresholds that must be satisfied for hydrogen production to qualify as 'Green', denoting its derivation from renewable sources. The notification explicitly outlines the MNRE's commitment to formulating a comprehensive methodology governing the measurement, reporting, monitoring, on-site verification, and certification processes for green hydrogen and its derivatives. Furthermore, the notification designates the Bureau of Energy Efficiency (BEE), under the Ministry of Power, as the Nodal Authority responsible for accrediting agencies engaged in the monitoring, verification, and certification of Green Hydrogen production projects (Ministry of New and Renewable Energy 2023).

5. India’s progress towards Green Hydrogen (Kanika Verma 2021)

- In 2020, the annual hydrogen demand in India amounted to 6 million tonnes (MT). Projections indicate that by 2030, hydrogen costs are anticipated to decrease by 50 per cent.
- Forecasts predict a five-fold surge in hydrogen demand to reach 28 MT by 2050, with an anticipated 80 per cent of this demand being environmentally sustainable or 'green' in nature.

• Notable industrial giants, including Reliance Industries Limited (RIL), Gas Authority of India Limited (GAIL), National Thermal Power Corporation (NTPC), Indian Oil Corporation Limited (IOCL), and Larsen and Toubro Limited (L&T), are strategically venturing into the green hydrogen sector. RIL aims to achieve net-carbon-zero status by 2035 and has committed to investing nearly INR 750 billion in Renewable Energy over the next three years.

• The government-led public sector undertaking (PSU), IOCL is spearheading the green hydrogen revolution with plans to establish India's inaugural green hydrogen unit for the Mathura Refinery, primarily dedicated to crude oil processing.

• NTPC has recently initiated a tender to develop an unprecedented hydrogen refuelling station in Leh, powered entirely by renewables through a standalone 1.25-megawatt solar system.

• Two hydrogen refuelling stations have been inaugurated, one at the IOCL's R&D Centre in Faridabad and the other at the National Institute of Solar Energy in Gurugram.

• India has articulated its aspiration to emerge as a hydrogen exporter to nations including Japan, South Korea, and Europe.

6. **Way Forward**

Hydrogen has emerged as a pivotal catalyst for India's energy metamorphosis, amplifying industrial prowess in a progressively decarbonising milieu. Its potential extends to economic growth, CO2 reduction, and heightened public health and well-being. On the international stage, India can spearhead the hydrogen economy, especially in mitigating hard-to-abate sector emissions.

As expenses decline and renewable energy gains momentum, the competitiveness of green hydrogen is on the ascent. The mounting pressures on carbon-intensive sectors, such as steel and refining, underscore the growing importance of hydrogen. Yet, persistent challenges necessitate cohesive endeavours in research, development, and infrastructure. Effective collaboration among policymakers, industry stakeholders, and financiers is imperative to propel the adoption of hydrogen, tackling issues related to production costs, storage, and regulatory ambiguities. By successfully navigating these challenges, India stands poised to assert global leadership in zero-carbon manufacturing, harmonising economic prosperity with environmental stewardship.

Bibliography

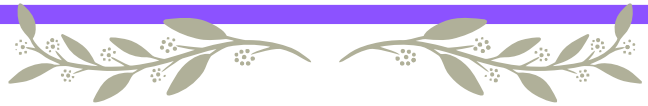
Kanika Verma. 2021. "Green Hydrogen- India's Sunrise Sector." INVEST INDIA. November 25. Accessed November 23, 2023. https://www.investindia.gov.in/siru/green-hydrogen-indias-sunrise-sector.

Ministry of New and Renewable Energy. 2023. Press Information Bureau. August 19. Accessed November 23, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1950421 .

—. 2023. "How National Green Hydrogen Mission seeks to Reduce Cost of Green Hydrogen." Press Information Bureau. August 9. Accessed November 23, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1947136 .

—. 2023. National Green Hydrogen Mission, office memorandum no.353/35/2022-NT dated 18th August 2023. August 18. Accessed November 23, 2023. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/aug/doc2023819241201.pdf .

—. 2022. "National Hydrogen Mission Decarbonising India, Achieving Net-Zero Vision." March 21. Accessed November 23, 2023. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/jan/doc2023110150801.pdf .



NITI Aayog and RMI Report. 2022. Harnessing Green Hydrogen. Report, NITI Aayog and RMI Report. https://www.niti.gov.in/sites/default/files/2022-06/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf.

World Economic Forum. 2021. What is green hydrogen and why do we need it? December 21. Accessed November 26, 2023. https://www.weforum.org/agenda/2021/12/what-is-green-hydrogen-expert-explains-benefits/ .

Algae Bloom as a Threat to Fisheries and Public Health

By: Kailash Chand Bajya, AAO

Figure 1: A duck wades through an algae bloom in Florida Source: (NRDC 2019)

Introduction

An algal bloom denotes the proliferation of microscopic algae or algae-like bacteria in freshwater, saltwater, or brackish environments.

Depending on the specific algae or bacteria responsible, the resultant algal bloom may give rise to malodorous scum, foam, froth, or a paint-like slick (Invasive Species Corporation 2023). Algae blooms, often characterised by rapid and excessive growth of algae in aquatic ecosystems, have become a pervasive environmental issue with far-reaching consequences. These blooms, typically driven by factors such as nutrient pollution, climate change, can pose significant threats to fisheries, the economy, and public health.

What is Harmful Algal Bloom?

Harmful Algal Blooms (HABs) are the result of the excessive proliferation of toxin-producing algae in a water source. These overgrown algal populations can manifest as visible blooms, which can appear in various colours like green, blue-green, red, or brown, depending on the algae species involved.

While some of these blooms are easily discernible due to their prominent appearance on the water's surface, others remain inconspicuous as they develop near the water body's bottom. Simply by visual inspection, it's not possible to determine whether a water body is afflicted by a harmful algal bloom (NIEHS 2023).

Advantages of Algae: Algae has several environmental benefits for humans and other species. One significant contribution is their ability to absorb and store the excessive carbon dioxide that humans release into the atmosphere, which helps in mitigating climate change. Beyond their environmental impact, algae are present in various everyday products, ranging from toothpaste to ice cream and dietary supplements. The inclusion of algae not only enhances the texture of these products but also brings about reported health benefits. This underlines the versatile nature of algae as a valuable resource in our daily consumption. Furthermore, substantial research investments by companies and agencies are directed towards exploring algal biofuels (Beck 2018).

I. Impact on Fisheries

Algae blooms can have severe repercussions for fisheries, which rely on healthy and balanced aquatic ecosystems to sustain their livelihoods. As algae proliferate, they consume oxygen in the water and create "dead zones" where fish and other aquatic organisms struggle to survive.

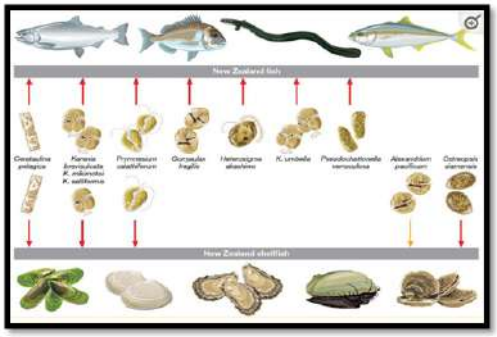


Figure 2: Known lethal and sublethal of harmful algal species that have bloomed on fish and shellfish in New Zealand. Arrows indicate blooms that have impacted both fish and shellfish Source: (Anne Rolton 2022)

Furthermore, some types of algae produce toxins harmful to fish, making the capture and consumption of seafood from affected areas dangerous for both fishers and consumers. Research conducted by the National Oceanic and Atmospheric Administration (NOAA) has shown that the economic losses for the United States (US) seafood industry due to harmful algae blooms can reach hundreds of millions of dollars annually. Such impacts can devastate local communities that depend on fishing for their economic well-being (NOAA 2021).

II. Economic Consequences

Algae blooms also carry significant economic costs beyond the fishing industry. Tourism and recreational activities often decline in areas plagued by unsightly and odorous algae blooms. For example, the harmful algal blooms in Lake Erie in 2014 forced Toledo, Ohio, to issue a "do not drink" advisory for the city's tap water, affecting over 400,000 residents (NWF, 2017). The economic toll of such crises includes lost revenue for local businesses and the substantial cost of water treatment and mitigation efforts.

III. Public Health Risks

Beyond their economic impact, algae blooms also pose a significant threat to public health. Harmful algal blooms can produce toxins that contaminate drinking water sources, leading to serious health issues when consumed. These toxins have been linked to a range of health problems, including vomiting, diarrhoea, confusion, seizures, permanent short-term memory loss, or death when consumed at high levels (NIEHS 2023).

The impact on public health extends beyond drinking water. Recreational exposure to algae-infested waters can result in skin and respiratory problems. Additionally, seafood contaminated by algal toxins poses a risk to consumers, making it essential to monitor and regulate seafood safety in areas susceptible to algae blooms.

Conclusion

Algae blooms represent a complex and growing threat to fisheries, the economy, and public health. Efforts to reduce nutrient pollution and combat climate change can help address the root causes of algae blooms and their associated challenges. Addressing this issue requires ongoing efforts to reduce nutrient pollution, combat climate change, and invest in research and technologies that enable more effective prevention and management of algae blooms. By doing so, we can protect the health of our aquatic ecosystems, fisheries, and the well-being of communities that depend on them.

Bibliography

Anne Rolton, Lesley Rhodes,Kate S. Hutson, Laura Biessy, Tony Bui, Lincoln MacKenzie,Jane E. Symonds, and Kirsty F. Smith. 2022. Effects of Harmful Algal Blooms on Fish and Shellfish Species: A Case Study of New Zealand in a Changing Environment. May 14. Accessed December 6, 2023. doi:10.3390/toxins14050341.

Beck, Whitney. 2018. When Algae Turns into “Too Much of a Good Thing”. December 06. Accessed December 05, 2023. https://sustainability.colostate.edu/humannature/whitney-beck/.

Invasive Species Corporation. 2023. Invasive Species Corporation. Accessed 12 14, 2023. https://invasivespeciescorporation.com/toxic-algae/.

NbcNews. 2014. 400,000 Scramble for Clean Water After Do-Not-Drink Warning in Toledo. March August. Accessed October 30, 2023. https://www.nbcnews.com/health/health-news/400-000-scramble-clean-water-after-do-not-drink-warning-n171441.

NIEHS. 2023. Algal Blooms. October 16. Accessed October 30, 2023. https://www.niehs.nih.gov/health/topics/agents/algal-blooms/index.cfm.

NOAA. 2021. Hitting Us Where it Hurts: The Untold Story of Harmful Algal Blooms. July 10. Accessed October 30, 2023. https://www.fisheries.noaa.gov/west-coast/science-data/hitting-us-where-it-hurts-untold-story-harmful-algal-blooms.

—. 2013. What is Harmful Algal Bloom. April 27. Accessed December 6, 2013. https://www.noaa.gov/what-is-harmful-algal-bloom.

NRDC. 2019. Freshwater Harmful Algal Blooms. August 28. Accessed December 6, 2023. https://www.nrdc.org/stories/freshwater-harmful-algal-blooms-101.

NWF. 2017. The Impacts OF Lake Erie's Harmful Algal Blooms on Great Lakes Buisnesses. Accessed October 30, 2023. https://www.nwf.org/-/media/PDFs/Regional/Great-Lakes/The-Impacts-of-Lake-Eries-Harmful-Algal-Blooms-on-Great-Lakes-Businesses-v3-062821.ashx?la=en&hash=FC1D272634990F464429B7841E6FE5E6EDDF7B5B.

Blue Economy, the Driving Force of India's Current Diplomatic Policy

By: Soumiti Modak, Accountant,
O/o Principal Accountant General (A&E), Kolkata, West Bengal

Introduction: "Blue Economy", the term was introduced by Gunter Pauli in his 2010 book "The Blue Economy: 10 years, 100 innovations, 100 million jobs". The concept began seeping into the consciousness of academics and policymakers after the United Nations Conference on Sustainable Development – the Rio+20 summit organised in Rio de Janeiro, Brazil in 2012. According to the World Bank, the Blue Economy is the "sustainable use of ocean resources for economic growth, improved livelihoods and jobs while preserving the health of ocean ecosystem".

Significance of Blue Economy for India: In the case of India, the Blue Economy plays a crucial role due to its vast coastline of over 7,500 km and an Exclusive Economic Zone (EEZ) of about 2.02 million square km. Ninety five per cent of India's trade volume transits by sea. Recently, the Union Minister of Science and Technology and Earth Sciences said that the Blue Economy is the sixth dimension of the Government of India's Vision of New India by 2030. The Quadrilateral Security Dialogue (QSD), commonly known as the Quad, was an informal alliance until 2021 of like-minded countries: the United States of America, India, Japan, and Australia formed in response to the Indian Ocean tsunami in 2004 regarding this purpose. Moreover, the 'Quad Plus' discussions on the COVID-19 pandemic in 2020 included the participation of South Korea, New Zealand, and Vietnam, indicating that the grouping is still evolving and may welcome new members shortly.

India's Blue Economy encompasses various components such as:

- Being the second-largest fish producer globally with an annual fish production of around 13 million metric tonnes, fisheries and aquaculture are major components of India's Blue Economy. India exports a significant portion of its seafood products, earning valuable foreign exchange. India has a National Fisheries Policy for promoting "Blue Growth Initiative" which focuses on sustainable utilisation of fisheries wealth from marine and other aquatic resources.
- With numerous ports facilitating trade and commerce, Marine transportation is another vital sector. The government has been investing in port infrastructure development to enhance connectivity and boost maritime trade. The "Sagarmala Project" is the strategic initiative for port-led development through the extensive use of IT-enabled services for the modernisation of ports. The vision of the Sagarmala Programme is to reduce logistics costs for Export-Import (EXIM) and domestic trade with minimal infrastructure investment. Sagarmala could boost India's merchandise exports to USD 110 billion by 2025 and create an estimated 10 million new jobs (four million in direct employment). The Ministry has started the ambitious Project of Sagarmala Seaplane Services (SSPS) with potential airline operators.
- Seabed mining is another aspect of India's Blue Economy. The country has significant deposits of minerals such as manganese nodules, polymetallic sulfides, and cobalt-rich ferromanganese crusts in its deep-sea areas. Exploration and extraction of these minerals can contribute to economic growth and energy security. India has an umbrella scheme by the name of "O-SMART" which aims at regulated use of oceans, marine resources for sustainable development. The country has ambitious plans for offshore wind energy projects and aims to harness the vast potential of ocean energy. These initiatives contribute to reducing carbon emissions, promoting clean energy, and addressing climate change concerns.

• Integrated Coastal Zone Management focuses on the conservation of coastal and marine resources, and improving livelihood opportunities for coastal communities etc. With its beautiful beaches, diverse marine ecosystems, and rich cultural heritage, India attracts a large number of domestic and international tourists. Coastal tourism generates revenue, employment, and promotes local development in coastal areas.

• Marine biotechnology is an emerging field with immense potential in India's blue economy. The country's rich biodiversity, including coastal and marine ecosystems, provides a vast resource for biotechnological research and development. Marine biotechnology can lead to the discovery of new drugs, bioactive compounds, and innovative solutions for various sectors.

• India emphasises promoting connectivity and trade through its "SAGAR" (Security and Growth for All in the Region) initiative. It aims to strengthen economic ties, infrastructure development, and enhance people-to-people contact with Indian Ocean littoral countries.

• India focuses on renewable energy sources like offshore wind energy and tidal energy contributes to reducing greenhouse gas emissions.

Blue Diplomacy: Blue diplomacy, also known as maritime diplomacy, refers to a country's diplomatic efforts and strategies in relation to its maritime interests and activities. Blue diplomacy will pave the way for India's aspiring blue economy goals, and its diplomatic ties with the Indian Ocean littorals will be pivotal in its blue pursuits. The Indian Ocean Rim Association (IORA), formerly known as the Indian Ocean Rim Initiative (IORI) and the Indian Ocean Rim Association for Regional Cooperation (IOR-ARC), an international organisation is formed with 23 countries with bordering the Indian Ocean.

India's diplomacy focuses on multiple aspects:

- Security and Defence: India aims to ensure the safety and security of its maritime domain, including protecting its Exclusive Economic Zone (EEZ) and vital sea lanes of communication. It actively participates in regional security frameworks like the IORA and Indian Ocean Naval Symposium (IONS) to enhance cooperation with other littoral states.
- India-Norway Task Force on Blue Economy for Sustainable Development: It was inaugurated jointly by both the countries in 2020 to develop and follow up joint initiatives between the two countries.
- Humanitarian Assistance and Disaster Relief (HADR): India actively engages in HADR operations in the region, providing assistance during natural disasters, such as cyclones, tsunamis, or floods. It has been involved in rescue operations and humanitarian aid distribution in neighbouring countries.
- Regional Cooperation: India actively engages in multilateral forums like the Indian Ocean Commission (IOC), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), and Indian Ocean Naval Symposium (IONS) to foster regional cooperation, address common challenges, and promote collective security.

Leadership in Blue Economy Initiatives: The Hon'ble President of India said at the occasion of 3rd Audit Diwas Celebrations in New Delhi, that India's leading position in the world community is visible not only in the field of audit during India's presidency of Supreme Audit Institutions 20 (SAI 20) but also in the list of the most powerful democratic countries by giving emphasis on the issues of Blue Economy and Responsible Artificial Intelligence.

Ocean Acidification as a Threat to Marine Life

By: Vikas Dhir, AAO

Definition: Ocean Acidification refers to a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO2) from the atmosphere (National Ocean Service 2023).

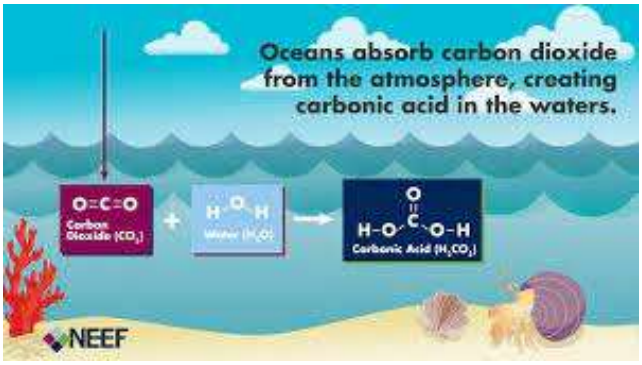


Image Source: U.S. Environmental Protection Agency

The Earth's oceans, covering 70 per cent of the planet's surface, are home to an astonishing diversity of life (United Nations, 2022). However, beneath the tranquil surface, a quiet yet insidious threat is taking hold – Ocean Acidification. This process, driven by human-induced changes in the Earth's atmosphere, has serious consequences for marine ecosystems.

Causes of Ocean Acidification

Ocean Acidification is a direct consequence of the increasing concentration of CO2 in the Earth's atmosphere. Carbon dioxide, a greenhouse gas, is primarily released through the following human activities:

- **Fossil Fuel Combustion:** The combustion of fossil fuels, such as coal, oil, and natural gas, for energy and transportation purposes is the largest source of anthropogenic CO2 emissions (Pierre Friedlingstein 2019).

- **Deforestation:** The loss of forests, which act as carbon sinks, reduces the planet's capacity to absorb atmospheric CO2.

- **Industrial Processes:** Certain industrial activities, like cement production and other process emissions (e.g., the production of chemicals and fertilisers) release CO2 directly into the atmosphere (Pierre Friedlingstein 2019).

Effects of Ocean acidification for Marine Life

The effects of Ocean Acidification on marine life are far-reaching and include the following:

Coral Reefs: Coral reefs, often called the "rainforests of the sea," are particularly vulnerable. Increasing ocean acidity disrupts the process of calcification, making it harder for corals to build their calcium carbonate skeletons (Anthony 2016). This can lead to the breakdown of entire reef ecosystems. Ocean Acidification poses a significant risk to coral reef ecosystems as it diminishes the supply of carbonate ions, which are essential for the growth of the skeletons of reef-building corals (Nathaniel R. Mollica 2018).

Just like humans need the right conditions to stay healthy, sea creatures also need the perfect balance inside their bodies. If the water they live in becomes acidic, their bodies have to work harder to stay healthy. This extra effort uses up energy that they could otherwise use to grow important body parts like muscles or shells. For instance, scientists discovered that mussels, sea urchins, and crabs sometimes have to break down their protective shells a bit to deal with the extra acidity in their bodies. So, even if these creatures can adapt to survive in more acidic water, it can still make them less healthy overall (USEPA, 2022).

Effects on Larvae: Marine creatures like fish and invertebrates go through complex life stages. They start as tiny larvae and grow while being carried away by ocean currents to different parts of the sea.

These larvae are incredibly small, and when the ocean becomes more acidic which makes them more vulnerable to acidity. For instance, sea urchin and oyster larvae don't grow as they should in higher acidity. In another case, fish larvae can't smell properly or avoid predators. Because these larvae are so delicate, it means that even if the adult organisms can reproduce, their young ones might not make it to adulthood (USEPA, 2022).

Pointers of Audit

In the course of audit on Ocean Acidification and its repercussions on marine life, Audit can actively examine impact of ocean acidification on Blue Economy. Scientific data, Government research reports on ocean acidity levels, assessment of their effects on marine ecosystems and government policies and regulations can be the criteria for carrying out such audits.

Audit assessment can begin with analysing Ocean Acidification trends, with a focus on monitoring changes in ocean pH levels over a defined timeframe. Audit can closely scrutinise its effects on marine ecosystems, carefully assessing the impact on vital species such as coral reefs, mollusks, and fish populations. Furthermore, the coordination among various government entities responsible for marine and environmental regulation can also be actively assessed. Lastly, Audit can also assess resource allocation, including budget and personnel, ensuring that it aligns with the scale and objectives of addressing this pressing issue. Audit can actively provide valuable insights and recommendations into the current state of Ocean Acidification and the measures in place to protect marine ecosystems.

Bibliography

Anthony, Kenneth R.N. 2016. Coral Reefs Under Climate Change and Ocean Acidification: Challenges and Opportunities for Management and Policy. July 27. Accessed November 29, 2023. doi:https://doi.org/10.1126/science.aac4722.

Nathaniel R. Mollica, Weifu Guonmollica, Anne L. Cohen, Kuo-Fang Huang, Gavin L. Foster, Hannah K. Donald, and Andrew R. Solow. 2018. Ocean acidification affects coral growth by reducing skeletal density. January 29. Accessed October 30, 2023. doi:https://doi.org/10.1073/pnas.1712806115.

National Ocean Service. 2023. What is Ocean Acidification? January 20. Accessed October 30, 2023. https://oceanservice.noaa.gov/facts/acidification.html.

Pierre Friedlingstein, Matthew W. Jones, Michael O'Sullivan, Robbie M. Andrew, Judith Hauck, Glen P. Peters, Wouter Peters, Julia Pongratz, Stephen Sitch, Corinne Le Quéré, Dorothee C. E. Bakker, Josep G. Canadell, Philippe Ciais, Robert B. Jackson, Peter. 2019. Global Carbon Budget 2019. Accessed October 30, 2023. https://essd.copernicus.org/articles/11/1783/2019/.

USEPA. 2022. Effects of Ocean and Coastal Acidification on Marine Life. November 9. Accessed October 30, 2023. https://www.epa.gov/ocean-acidification/effects-ocean-and-coastal-acidification-marine-life.

United Nations. 2022. While Oceans Cover 70 Per Cent of Earth's Surface, Understanding Has Lagged, Speakers in Lisbon Dialogue Stress, Offering Ways to Close Knowledge Gap. June 30. Accessed October 30, 2023. https://press.un.org/en/2022/sea2152.doc.htm.

By: Vikas Dhir, AAO

The Black Drongo

Photo Credit: Capt. Shashank (Dy. Chief Mechanical Engineer-North Western Railway)

The Black Drongo (Dicrurus macrocercus) is a small passerine bird native to Asia, recognised for its assertive nature when confronted by larger birds encroaching upon its territory. These birds exhibit a striking glossy black plumage and sport a distinctive deeply forked tail. Possessing short legs, they typically maintain an upright posture on thorny bushes, bare perches, or electrical wires. In some instances, they can be observed perching on the backs of grazing animals. These birds are known to be summer visitors to North-eastern Afghanistan and Northern Pakistan, while maintaining residency from the Indus Valley through Bangladesh, extending into India and Sri Lanka. The Black Drongos are adaptable to various environments, including open landscapes like savannas, shrublands, grasslands, fields, and even urban areas. Their ability to thrive in diverse habitats contributes to their widespread distribution across the Indian subcontinent (Animalia n.d.).

The Indian Robin

Photo Credit: Capt. Shashank (Dy. Chief Mechanical Engineer-North Western Railway)

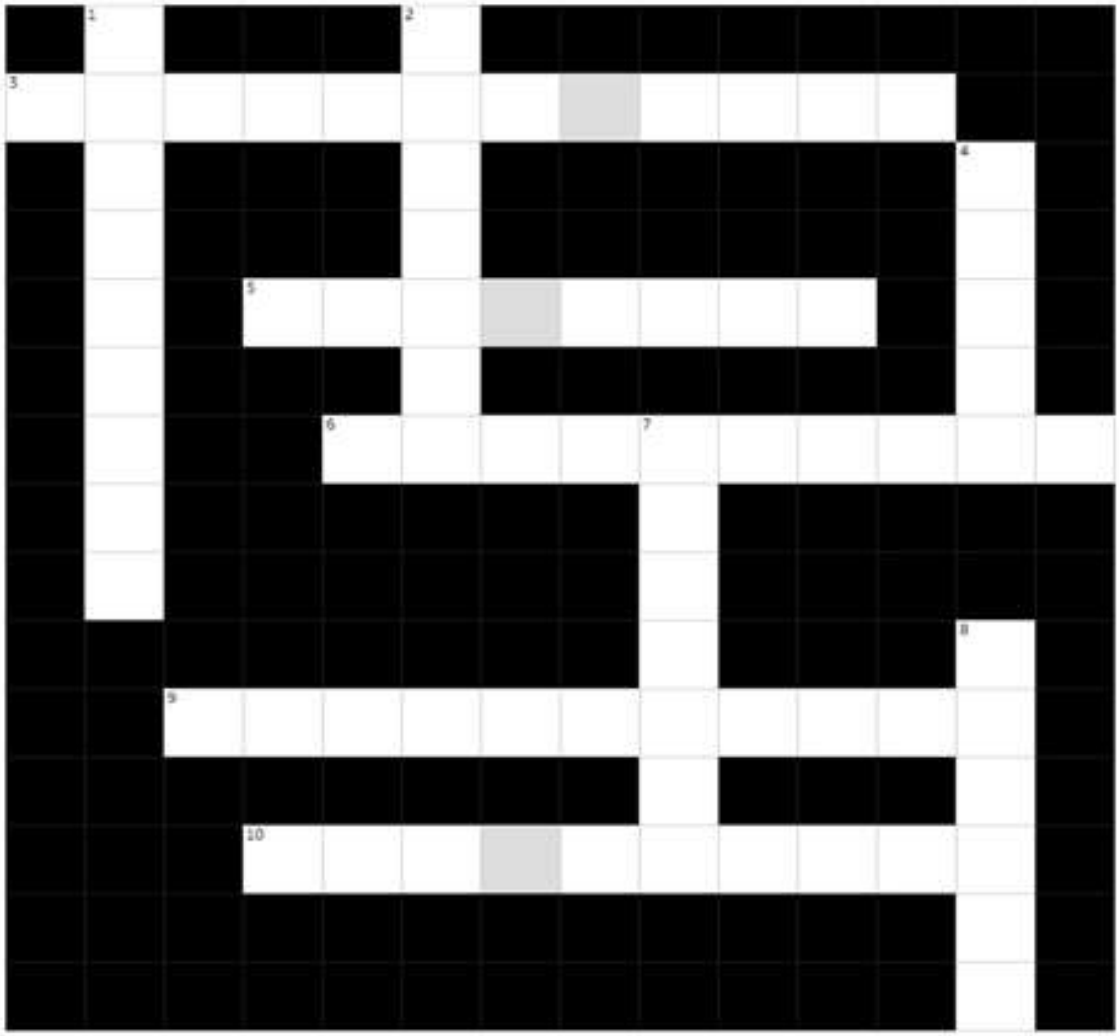
The Indian Robin (Copsychus fulicatus) belongs to the Muscicapidae family and is a prevalent bird species across the Indian subcontinent, spanning Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Thriving in open stony, grassy, and scrub forest environments, these birds exhibit a preference for dry habitats and are notably less common in denser forest areas with high rainfall. The Indian Robin is a resident species, displaying a non-migratory behaviour throughout its range. These birds often establish their presence near human settlements and can be frequently observed perching on rooftops. Their adaptability to coexist with human habitation underscores their versatility in habitat selection (Animalia n.d.).

Bibliography

Animalia. n.d. Accessed November 24, 2023. https://animalia.bio/.

Cross the Blue Word

By: Vikas Dhir, AAO



Questions:

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1. As water temperature increases, the pH level_____.

2. The form(s) of nitrogen present in water is/are_____.

3. The two primary divisions of Marine eco-system are benthic (substratum) and_____.

4. Seaweed is used as staple food in_____.

5. Biodiesel is produced from_____.

6. What ecosystem service refers to the ability of coastal habitats to capture and store atmospheric carbon dioxide?_____.

7. Dynamical theory of tides was proposed by_____

8. Indian Sundarbans is designated as World Heritage Site by_____.

9. Oil and natural gas are_____ deposits that occur naturally within thick sedimentary sequences

10. Continental shelves are flat areas with an average depth of_____.

Answers:

Across:

3. Pelagic Zone

5. Sea Weed

6. Regulating

9. Hydrocarbon

10. 130 metres

Down:

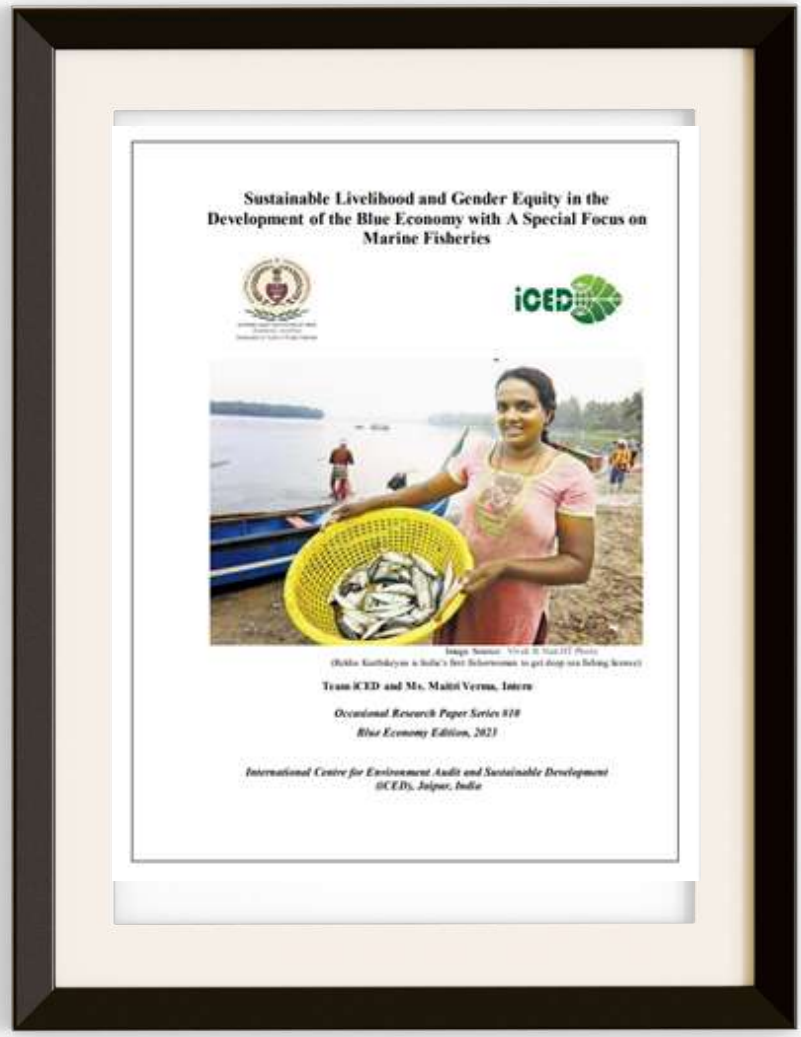
1. Decreases

2. Nitrate

4. Japan

7. Laplace

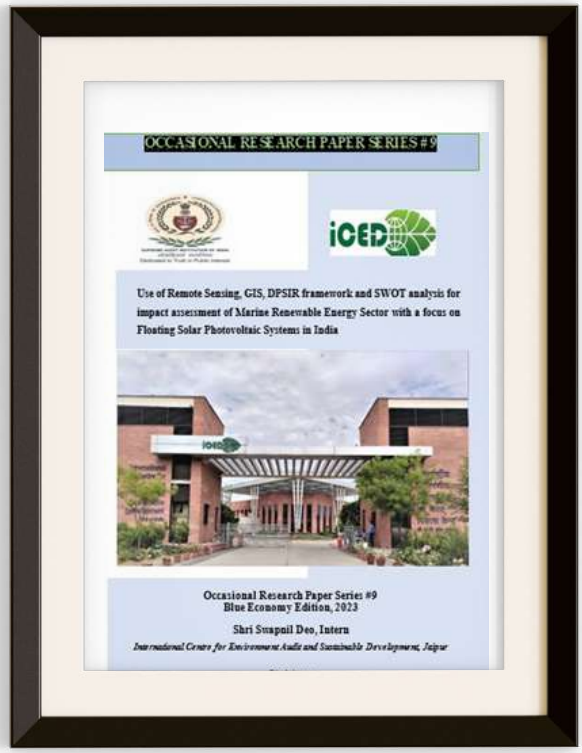
8. UNESCO



The research paper "Sustainable Livelihood and Gender Equity in the Development of the Blue Economy with A Special Focus on Marine Fisheries" signifies the important role that Gender Equity plays in today's socio-economic conditions and highlights the challenges that women face, especially focusing on fisheries.

This research paper serves as a valuable tool to identify areas to be strengthened and new approaches to be developed in the Blue Economy sector in general. It would be of particular relevance to gender auditing in the marine fisheries sector.

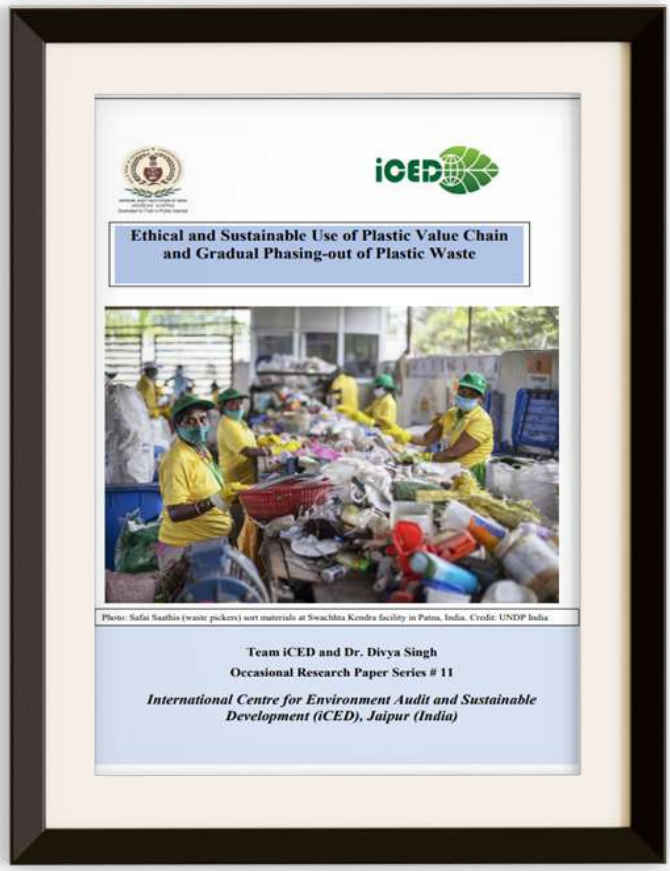
The research paper can be accessed at: https://iced.cag.gov.in/wp-content/uploads/Final%20copy%20approved%20Ms.%20Maitri%20Verma%2006.09.2023.pdf



The research paper "Use of Remote Sensing, GIS, DPSIR Framework and SWOT Analysis for Impact Assessment of Marine Renewable Energy Sector with a focus on Floating Solar Photovoltaic Systems in India" highlights the Global and Indian Floating Solar Photovoltaic (FSPV) systems through a case study approach.

Further, an assessment of environmental aspects relating to the marine renewable energy sector, especially focusing on Floating Solar Photovoltaic Systems in India using DPSIR framework work (Drivers, Pressures, State, Impacts, and Responses) and a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) has also been incorporated in this case study.

The research paper can be accessed at: https://iced.cag.gov.in/wp-content/uploads/Swapnil%20paper_revised_ORP_11-08-2023%20Final%201.0.pdf



The research paper ““Ethical and Sustainable Use of Plastic Value Chain and Gradual Phasing-out of Plastic Waste” highlights the role, discusses various barriers as well as challenges to the Plastic Value Chain and informs ways to improve the Circular Economy of plastics by introducing the element of ethicality and sustainability to its usage.

Further, it explores the critical imperative of transitioning towards an ethical and sustainable plastic value chain while progressively reducing plastic waste

The research paper can be accessed at: https://iced.cag.gov.in/wp-content/uploads/Final.%20Divya%20Research%20Paper%20Approved%20by%20ADAI(1).pdf

"More than half of the world's population lives near a coastline,primarily due to proximity to maritime transportation. This puts pressure on coastal environments and makes communities exceptionally vulnerable to sea level rise and increasing frequency and severity of storms due to climate change. Mitigating and adapting to these realities is crucial to maintaining a healthy economy and presents multiple buisness opportunities"

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SOURCE:- (BOLD BUISNESS, 2019)

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