UDA WORKSHOP FOR GOVERNMENT OFFICIALS

Maritime Research Center and Ministry of Environment, Forest and Climate Change

Held on:

November 19-21, 2025

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List of important topics covered

Executive Summary:

The Maritime Research Centre (MRC), in collaboration with the Ministry of Environment, Forests, and Climate Change (MoEF&CC), successfully conducted a 3-day Underwater Domain Awareness (UDA) Workshop for Indian government officials at our UDA Centre in Pune, Maharashtra. This workshop was organised under the "Forestry Training and Capacity Building" scheme of MoEF&CC to empower Government Officers with the knowledge and tools to manage marine and freshwater systems effectively. It further aimed to strengthen national capacity and capability to understand and manage the underwater domain, which holds critical strategic, environmental, and socio-economic significance for India. The workshop was designed as an introductory engagement that would familiarise participants with the core principles of the UDA framework (explained in the 'Annexture' section) and its relevance to India's maritime governance. The sessions provided a structured roadmap for informed participation in the UDA ecosystem, enabling stakeholders to identify opportunities for collaboration, innovation, and policy integration.

A key highlight of the workshop was its strong focus on project-based learning. Drawing on India's diverse coastal and riverine settings, the sessions illustrated how local research and homegrown technological solutions can support practical, informed decision-making. Discussions throughout the workshop centred on critical priorities such as Climate Resilience, Shipping-Radiated Noise Management, Sediment Management, Sustainable Development, and Digital Transformation, all viewed through the lens of Marine Spatial Planning (MSP). The interactions enabled meaningful dialogue among participants from diverse sectors, underscoring the importance of a coordinated, science-led approach to managing the underwater domain. This engagement has helped build a stronger understanding of the UDA framework and its relevance to national governance. With increased awareness and collaboration, the workshop is expected to encourage broader participation in future UDA activities nationwide. The overall learning experience was thoughtfully designed, beginning with core concepts on Day 1, moving into detailed technical and thematic sessions on Day 2, and concluding with a field visit on Day 3 that brought many of the discussions into a real-world context.

Day 1 opened with a session on UDA as an environmental necessity, highlighting how underwater sensing, acoustics, and data can support better governance. The day also introduced participants to the link between the Blue Economy and MSP, the digital UDA platforms developed at MRC, and community-focused initiatives designed to support coastal and riverine livelihoods. Day 2 focused on maritime security, sustainable aquaculture, and inland water management. Participants were shown how tools like MSP and modelling techniques can help understand sediment flow, river dynamics, and the broader geopolitical context influencing coastal communities. Day 3 coincided with World Fisheries Day and included a field visit to the Bhigwan Flamingo Sanctuary at Ujani Dam. This provided a real-world perspective on freshwater biodiversity, fisheries-based livelihoods, and community-driven conservation, reinforcing the practical value of the concepts discussed throughout the workshop.

Introduction:

The Indian Ocean Region (IOR), characterised by complex tropical marine and freshwater ecosystems, presents unique environmental and operational challenges. The underwater domain in these regions is influenced by unpredictable medium variability, limited visibility, and site-specific ecosystem behaviour, making traditional, land-based approaches insufficient for accurate monitoring and effective governance. Acoustics remains the only reliable means to observe below the water surface, with sonar serving as the primary tool for processing underwater signals. However, technologies designed for temperate waters, particularly imported sonar systems, experience nearly 60% performance degradation in tropical conditions, underscoring the need for indigenous solutions tailored to local realities.

The region's dynamic sediment transport, coastal erosion, flooding vulnerabilities, navigability constraints, biodiversity richness, and resource potential further demand an integrated scientific and policy-driven approach. Without a comprehensive understanding of the underwater domain, remote sensing and other monitoring tools face significant limitations. Underwater Domain Awareness (UDA) emerges as a strategic framework to bridge these gaps by combining acoustic capability, advanced sensing, data-driven governance, and cross-sectoral collaboration. Marine Spatial Planning (MSP), as a leading digital transformation tool in this space, enables coordinated decision-making and optimal deployment of national resources across stakeholders. Together, UDA-driven MSP provides a structured pathway to strengthen sustainability, climate resilience, disaster preparedness, and Blue Economy growth in India.

Building capacity and capability is essential to ensure that decision-makers across ministries and agencies can address underwater challenges with confidence and clarity. Project-based learning rooted in site-specific research and technological innovation offers the most effective route for developing such expertise.

The workshop helped participants develop a stronger understanding of how underwater ecosystems are closely linked to national security and the livelihoods of coastal and riverine communities. It highlighted the importance of using technology, integrated data, and coordinated efforts among government agencies to manage underwater resources more effectively. With representation from various national institutions, the sessions encouraged meaningful collaboration and emphasised the need for a structured UDA framework to guide policy and operational decisions. The program wrapped up with a collective resolve to reinforce national capacity, promote science-led maritime governance, and support the UDA mission as an essential driver of environmental resilience and Blue Economy development in India.

Workshop Overview:

The 3-day UDA Workshop, organised by our team in collaboration with the MoEF&CC, was designed to strengthen scientific understanding and governance capabilities related to tropical underwater ecosystems among government officers. Participants represented diverse national institutions engaged in coastal management, biodiversity conservation, inland water governance, hydrography, climate risk, and disaster response.

The core objectives of the workshop were to:

- Build a comprehensive understanding of the UDA framework and its relevance to maritime security priorities
- Highlight the role of underwater sensing, acoustics, and digital platforms in ecological monitoring and decision support
- Strengthen the capacity of government officers for data-driven planning, MSP, and Blue Economy interventions
- Promote inter-agency coordination for the holistic management of underwater resources
- Encourage field-based perspectives by linking scientific insights to community livelihoods and conservation needs
- Facilitate an actionable roadmap for mainstreaming UDA into policy and operational mandates

The program followed a structured and progressive learning approach. **Day 1** introduced the foundational concepts of UDA with a strong focus on environmental applications. Through a series of expert-led sessions, participants examined the role of underwater sensing, acoustics, artificial intelligence, and digital platforms in strengthening underwater domain awareness. The day also showcased ongoing UDA initiatives and highlighted opportunities for community-level capacity building.

Day 2 transitioned into domain-specific applications, connecting UDA with climate risk management, aquaculture, sediment transport, inland water governance, and geopolitics in the Indian Ocean Region. Demonstrations of Marine Spatial Planning (MSP) tools enabled participants to interact with data-driven platforms that visualise underwater variables to improve decision-making and resource management.

To reinforce classroom learning with real-world context, **Day 3** featured a field visit to Bhigwan Flamingo Sanctuary on the Ujani Dam backwaters. Aligned with World Fisheries Day, the visit enabled participants to witness the direct relationship between freshwater biodiversity, fisheries-dependent livelihoods, and environmental stewardship. The field interaction encouraged practical reflections on how UDA-based technologies and governance approaches can support local ecosystems and vulnerable communities.

Across all three days, the workshop effectively illustrated how UDA provides a unifying framework to connect terrestrial, coastal, and marine environments; enable inter-agency coordination; and drive data-led governance in India's tropical waters. Participants gained not only conceptual clarity but also practical insights into integrating UDA-driven MSP approaches within their respective institutional mandates.

Day-wise proceedings of the sessions:

Day 1:

Day 1 focused on setting the context for UDA in tropical waters, establishing scientific fundamentals, and highlighting strategic priorities for environmental governance.

Topic 1: Underwater Domain Awareness (UDA) as an Environmental Imperative

This session was hosted by the Founder and Director of the MRC, Dr (Cdr) Arnab Das. His opening remarks highlighted that Underwater Domain Awareness (UDA) must be seen as an environmental and resource-management imperative rather than a purely strategic or military construct. He underscored that the underwater space, especially in the tropical littorals, is fundamental to ecological sustainability, economic growth, and national resilience. Dr Das introduced participants to the Four-Stakeholder Approach, which lies at the core of the UDA framework. The approach recognises that the underwater domain is shared by multiple sectors whose activities are deeply interlinked:

National Security Agencies: Ensuring safe seas requires enhanced surveillance and monitoring capabilities in the underwater space. Dr Das highlighted that asymmetric threats, stealth activities, and maritime border challenges demand advanced acoustic-based technologies and strong inter-agency coordination.

Blue Economy Stakeholders: Industries such as fisheries, aquaculture, offshore energy, seabed resources, and maritime infrastructure development rely heavily on underwater knowledge. UDA enables these sectors to operate more efficiently while reducing conflicts over space and resources.

Marine Environments and Disaster Management Entities: Tropical waters hold rich biodiversity but remain susceptible to coastal erosion, habitat degradation, and climate-driven disasters such as storm surges and tsunamis. UDA provides critical insights for marine ecosystem protection, coastal resilience planning, and early warning systems.

Science and Technology Providers: Research institutions, innovation centres, start-ups, and technology developers are pivotal in building an indigenous and affordable underwater technology ecosystem. Their efforts help reduce dependency, build capacity, and promote Atmanirbharta in underwater sensing, data analytics, and maritime research.

He also stressed the need for skilled human resources, noting that trained personnel are essential to operate underwater systems, interpret data, and translate insights into actionable solutions. Capacity-building programs like this workshop help government officers become enablers of change in their respective ministries. Ultimately, the session encouraged participants to view the underwater domain not as an isolated strategic frontier, but as a critical national asset that supports livelihoods, innovation, sustainability, and long-term socio-economic security.

Here is the link to the full video: https://t.ly/eGKwV

Topic 2: Blue Economy and Marine Spatial Planning (MSP): Policy Interventions through a UDA Lens

The speaker for this session was Ms Cathrine J, Head of Research and Publications at the MRC. This presentation highlights the critical roles of IFS and non-IFS officers in India's Blue Economy and Marine Spatial Planning (MSP), emphasising that forests, rivers, estuaries, mangroves, and marine ecosystems form a continuous land–sea continuum.

It explains how fragmented governance, land-based pollution, climate shocks, and tropical acoustic challenges are undermining sustainable marine management, and positions the UDA framework as the missing technological and policy link to enable data-driven, integrated ocean governance. By combining MSP with UDA, the presentation demonstrates how habitat mapping, pollution monitoring, sediment management, mangrove protection, fisheries sustainability, and marine mammal conservation can be strengthened, especially in tropical and resource-constrained conditions.

It further connects national initiatives like ICZM, the Deep Ocean Mission, and the National MSP program with the responsibilities of relevant departments, recommending stronger land–sea planning integration, capacity building, joint enforcement, and community engagement, ultimately presenting forest officers as key stakeholders and ecological custodians in India's sustainable Blue Economy pathway.

Here is the link to the full video: https://t.ly/ueAw2

Topic 3: AI-Driven Modelling & Simulation-based Marine Spatial Planning: A Strategic Approach for India in the Indian Ocean Region

The speaker for this session was Mr Shridhar Prabhuraman, Deputy Director, MRC. At the beginning of his presentation, the speaker introduced **Marine Spatial Planning (MSP)** as a structured way to organise human activities at sea—fishing, shipping, tourism, and conservation—so they do not conflict with one another or damage marine ecosystems. They contrasted traditional zoning-based MSP, using the Great Barrier Reef as an example, with India's emerging MSP efforts under the Indo–Norway Initiative, highlighting India's 2 million km² EEZ and its strategic, ecological and economic importance.

They then unpacked institutional and policy gaps in India: fragmented governance across ministries, weak Environmental Impact Assessments that ignore cumulative and long-term impacts, and poor data sharing. Real-world coastal erosion and stakeholder conflict cases from Tamil Nadu and port development were used to show how static, siloed planning can worsen erosion, damage livelihoods, and miss early warning signals.

From there, the talk built the case for modelling & simulation–based MSP, arguing it offers dynamism (adapting to changing marine and climate conditions) and impact modelling (testing "what if" scenarios for dredging, marine traffic, ports, etc.). The speaker presented a conceptual decision-support stack comprising real-time data streams, simulation engines, impact analysis, and interactive interfaces, illustrated by a Shipping Radiated Noise (SRN) mapping tool developed by NirDhwani.

The presentation then moved into AI and data-driven methods: explaining basic AI/ML concepts (supervised/unsupervised learning, regression, classification) with playful analogies and domain examples such as sediment classification and ship-noise prediction models.

Finally, the speaker connected forest–coast–ocean linkages, emphasising how hydrology, sediment, and nutrients from upstream forests shape coastal resilience. Examples included Godavari delta erosion after damming and the 2018 Kerala floods' sediment spike. The talk concluded by showcasing ongoing work in sediment management, URN mapping, acoustic habitat mapping, flood risk, vessel path prediction, and aquaculture analytics. It framed a technology-enabled, UDA-driven MSP platform as a strategic necessity for India's sustainable ocean governance.

Here is the link to the full video: https://t.ly/flVAK

Topic 4: MSP Handbook and Policy Frameworks for Forest and Coastal Governance

The speaker for this session was Ms Cathrine J, Head of Research and Publications at the MRC. This was her second presentation of the day. The presentation introduces the Marine Spatial Planning (MSP) Handbook, developed under the UDA Framework, and positions oceans as critical to climate regulation, economic productivity, and maritime security, while highlighting the growing challenges of resource competition, governance fragmentation, and overexploitation. It argues that effective MSP must integrate policy, technology, and capacity-building, especially in resource-constrained and tropical regions like the Indian Ocean, where Western, hardware-heavy models are often unsuitable.

By combining low-cost innovations, modelling & simulation tools, indigenous data analytics, and acoustic capacity building, the proposed framework aims to enable inclusive, climate-responsive, and secure ocean governance. The handbook outlines a three-pillar roadmap — policy interventions, technology interventions, and capability development — aligned with ESG principles and SDGs, with a future vision centred on harmonising People, Economy, and Nature through outreach, engagement, and sustainable practices.

Link to the full presentation: https://t.ly/D-oFq

Topic 5: Implementation of the UDA Framework through '100 Warriors' initiative

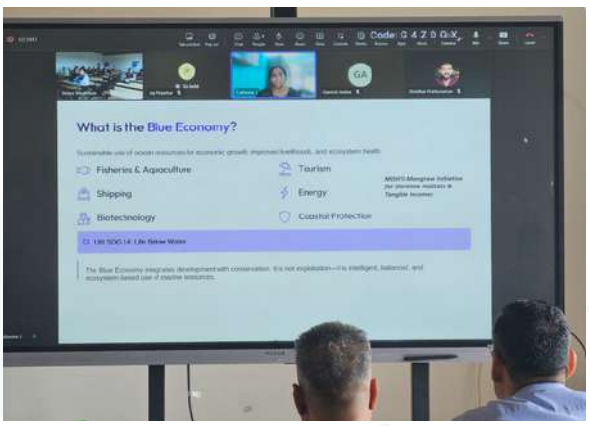
The speaker for this session was Ms Nishtha Vishwakarma, Head of Communication and Outreach, the MRC. She began by introducing the '100 Warriors' Initiative, which has been strategically developed by integrating three critical streams of engagement: the 100 Coastal Warriors, 100 River Warriors, and 100 Water Warriors programmes. Together, these initiatives aim to build a nationwide cadre of empowered champions capable of driving UDA-led sustainable development across diverse aquatic ecosystems.

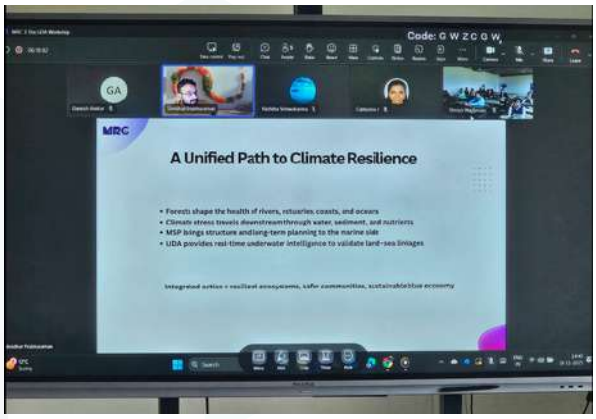
Ms Nishtha explained that the initiative focuses on strengthening community-driven stewardship by involving local youth, researchers, administrators, and frontline agencies. These "Warriors" are equipped with contextual knowledge of underwater ecosystems, socio-economic dependencies, and emerging technological interventions. She emphasised that the initiative not only builds awareness but also enables these individuals to become active contributors to marine and riverine conservation and responsible resource utilisation.

She highlighted that the Warriors are trained through structured capacity-building modules, technical exposure visits, and project-based learning. Each participant is encouraged to identify real-world challenges, from plastic pollution and habitat degradation to fisheries management and underwater noise, and work collaboratively toward implementable solutions. This approach creates a ripple effect of change, amplifying local participation in environmental governance.

Ms Nishtha also pointed out that the integration under the 100 Warriors initiative allows MRC to expand its reach across the entire Indian coastline and inland waterways, ensuring that no geographical community is left behind. The initiative prioritises inclusivity by engaging students from coastal and riverine districts, empowering them with access to scientific tools, mentorship, and innovation platforms that were previously unavailable to many.

Here is the link to the full video: https://t.ly/SaB9_





Day 2:

During sessions on Day 2 of the UDA Workshop, speakers delved into diverse themes, including ecosystem productivity, maritime security, sustainable aquaculture, sediment and watershed dynamics, and biodiversity protection. They linked them to livelihoods and resilience-building for communities. Discussions further expanded into regional geopolitics and community engagement in the Indian Ocean Region, reinforcing the importance of collaboration for shared ecosystem stewardship. The day concluded with a hands-on demonstration of the Marine Spatial Planning (MSP) Tool, showcasing its potential to integrate underwater and terrestrial data for holistic environmental management under the UDA framework.

Topic 1: Enabling UDA Operations: Infrastructure, Technology, and Policy Framework for Autonomous Underwater Systems

Dr. (Cdr.) Arnab Das highlighted that the successful execution of UDA-driven operations requires a holistic and well-designed operational ecosystem. He underscored the significance of robust infrastructure, including suitable deployment platforms, sonar-equipped vessels, and launch-and-recovery mechanisms tailored to different types of autonomous underwater vehicles (AUVs). Matching the vehicle's capabilities to mission objectives, whether for surveillance, environmental monitoring, or target recovery, is essential.

He further emphasised the need for comprehensive environmental and physical data collection to support mission planning. Parameters such as ocean and river currents, sound velocity profiles, seabed composition, water depth, and proximity to shore inform equipment selection, navigation, and operational safety. Dr Das stressed that requirements should originate with domain users rather than vendors: stakeholders must clearly define operational needs and expected outcomes before identifying suitable technological solutions. He also highlighted organisational considerations, including communication interoperability, centralised vs. decentralised deployment models, capability development, and coordination among multiple agencies.

Overall, the session reinforced that operationalising UDA capability is a structured, phased process that involves policy alignment, technology readiness, and skilled human resources, collectively enabling timely, efficient, and mission-driven underwater operations.

Here is the link to the full video: https://t.ly/h2rO4

Topic 2: UDA-Based Sediment Management in the Tropical Indo-Pacific

This session was addressed by Romit Kaware, a Research Fellow at MRC, whose work focuses on Sediment Management in the tropical waters of the Indo-Pacific. During his session, Romit highlighted the importance of sediment management in the tropical Indo-Pacific region, characterised by warm sea temperatures, shallow acoustic waters, rich biodiversity, and high monsoon-driven sediment influx. He further highlighted that these unique tropical conditions intensify sediment transport, biofouling, turbidity, and coastal erosion, factors that collectively influence ecosystems, navigation safety, and socio-economic stability. These complexities make sediment management indispensable for sustaining ports, inland waterways, urban centres, and strategic maritime operations.

During his presentation, Romit introduced the audience to the concept of sediment management, framing it around its two foundational components: sediment transport modelling and sediment classification. Sediment management provides a scientific and operational understanding of how sediment moves, settles, and interacts with both natural systems and human-built infrastructure. Moving into the first technical pillar, the speaker elaborated on sediment transport modelling, explaining how it enables predictions of shoaling, erosion hotspots, navigation bottlenecks, reservoir siltation, and flood-prone urban zones. Such modelling is essential for maintaining harbour depths, mitigating urban flooding, and protecting coasts from monsoon-induced erosion.

The discussion then shifted to sediment classification, which can be supported by acoustic, remote, and machine learning methods. The speaker explained its value for evaluating sediment-bearing pressure, offshore engineering viability, benthic ecosystem conditions, and sectors such as polymetallic nodule mining and amphibious operations. He also cited specific examples, including the acoustic and sediment classification studies conducted by MRC in Khadakwasla and Ujjani Reservoirs, to demonstrate the real-world applicability.

In the final segment, Romit outlined an integrated UDA-based approach to sediment management. He described how sediment transport models, classification layers, ecological information, and strategic overlays can be collectively organised within an MSP framework. By incorporating local community knowledge, this system enables localised, real-time, information-driven sediment management—ultimately supporting sustainable economic growth, improved disaster response for agencies like NDRF, enhanced riverine mobility for BSF, and stronger environmental resilience across the Indo-Pacific.

Here is the link to the full video: https://t.ly/K8YL0

Topic 3: Aquaculture and Inland Water Systems through the UDA Perspective

This presentation provided an insightful overview of coastal ecosystem dynamics and the evolving role of the Blue Economy in enhancing coastal livelihoods and national economic growth. The session highlighted the interdependence between coastal biodiversity, industry, and community resilience, noting both the immense opportunities and emerging challenges in sustainably managing coastline resources. In recognition of World Fisheries Day, the presenter emphasised the growing national and global relevance of fisheries and aquaculture, not only as a source of nutrition and employment but also as a major contributor to India's export economy. Despite strong export figures, the presenter pointed out persistent productivity gaps compared to developed nations, indicating inefficiencies and unsustainable utilisation of natural resources.

Through a decade-long trend analysis, the session noted that while states like Andhra Pradesh have significantly boosted production, overall productivity has largely stagnated. This has driven unchecked expansion of aquaculture areas, often at the expense of ecologically sensitive zones such as mangroves and wetlands, creating long-term environmental and socio-economic risks. To address these concerns, the presenter proposed a shift toward technology-enabled productivity enhancement, better spatial planning, and policy measures that balance industrial development with environmental conservation. The presenter underscored the need to optimise existing resources rather than expand into protected ecosystems, ensuring equitable growth for farmers and coastal communities.

The presentation concluded by showcasing our contributions through UDA-driven innovations in sustainable aquaculture and fisheries management, leveraging scientific tools and spatial intelligence to promote a more resilient, environmentally responsible Blue Economy.

Topic 4: Integrating ASEAN heritage with Underwater Domain Awareness for regional water security and resilience

Professor Mimi Fabe, MRC Research Fellow, delivered a unique and insightful discourse that connected the UDA framework with the values embodied by three iconic ASEAN figures — Dr José Rizal of the Philippines, Prince Diponegoro of Indonesia, and King Bhumibol Adulyadej of Thailand. She highlighted how UDA reflects core ASEAN principles of community service, resilience, and sustainable development. Referencing Dr. Rizal's legacy of service, multidisciplinary excellence, and commitment to public welfare, she emphasised that UDA similarly prioritises the well-being of coastal communities by ensuring safe water systems, supporting inclusive capacity building, and enabling community-centric applications across the region.

Drawing parallels with Prince Diponegoro's foresight and warrior spirit, she noted that UDA's modelling capabilities enable prediction, preparedness, and continuous enhancement of national maritime resilience. The framework empowers ASEAN nations to anticipate environmental changes, manage resources proactively, and strengthen security in marine and inland water spaces. King Bhumibol's leadership on unity, sustainable development, and accessibility was linked to the scalability and adaptability of the UDA approach. Ms Fabe stressed that UDA integrates advanced technologies, including AI and analytics, while remaining rooted in local cultural contexts, stakeholder participation, and knowledge-driven growth.

She further outlined UDA's practical potential in addressing shared regional challenges: forecasting water consumption, managing contamination risks such as arsenic, enhancing drinking water quality, and enabling efficient water utility operations across ASEAN. In closing, she reaffirmed that UDA, when aligned with ASEAN's rich heritage and collective aspirations, serves as a transformative tool for building water-resilient, stable, and prosperous communities.

Here is the link to the full video: https://t.ly/38aox

Topic 5: Empowering Indigenous Sea Communities

Ms Andrea Toledo, MRC Research Fellow, delivered a powerful and inspiring discourse that highlighted the indispensable role of indigenous maritime communities, such as the Bajau Laut, in strengthening ocean stewardship, maritime security, and blue economy initiatives across the Indo-Pacific. Drawing from her academic and counter-terrorism expertise, as well as her lineage of sea warriors, she contextualised UDA as a human-centric framework rooted in empowerment, dignity, and sovereignty.

She emphasised that coastal and sea-dependent populations hold centuries-old indigenous navigation knowledge, reading the stars, wind, and waters, which, when combined with India's emerging low-cost ocean technologies, can transform them into frontline guardians of marine ecosystems.

Ms Toledo also highlighted several practical intervention pathways:

1. **Community-driven Early Warning Systems:** Integrating acoustic sensors with real-time intelligence from sea-dwelling communities for detecting cyclones, rogue waves, illegal fishing, and grey-zone maritime threats.
2. **Fisheries Regeneration & Ecosystem Protection:** Mapping breeding grounds, migration corridors, and reef health using low-cost buoys, diver-led surveys, and UDA analytics.
3. **Governance Inclusion:** Recognising indigenous rights, ensuring representation in marine management councils, and treating sea peoples as strategic partners rather than invisible populations.

She reinforced that the goal is not dependence or charity, but restoring dignity through access to technology, training, and decision-making power because empowerment is the antidote to exploitation, and integration is the antidote to invisibility. Her closing remarks appealed to the collective responsibility of Indo-Pacific nations to rebuild a "kingdom of stewardship — not of walls, but of waves", honouring the memory, culture, and custodianship of sea communities erased by colonial history.

Here is the link to the full video: https://t.ly/dZCud




Day 3:

Field Site: Bhigwan Flamingo Sanctuary, Ujani Dam Backwater

Day 3 of the UDA Workshop focused on contextual field learning designed to reinforce the theoretical and technological concepts covered during the first two days.

The field engagement enabled participants to directly connect UDA-driven environmental governance principles with practical observations from a dynamic freshwater ecosystem. The delegation, including officials from NDRF, BSF, ICAR, and the Fisheries Department, was welcomed by Dr. Erach Bharucha, a distinguished environmentalist and pioneer in wildlife education in India. Through informal interaction and structured dialogue, Dr. Bharucha outlined:

- The evolution of wetland conservation in India
- Local livelihood dependencies and freshwater ecosystem dynamics
- Insights from historical habitat restoration efforts and biodiversity management practices
- The importance of field-derived ecological understanding in policy formulation

A guided boat safari allowed officers to observe migratory birds and wetland biodiversity while discussing:

- Ecological indicators of freshwater health
- Feeding patterns and habitat behaviour of flamingoes and associated species
- The linkages between biological observations and UDA parameters, such as acoustic behaviour, water quality, and habitat productivity

This hands-on learning emphasised that effective environmental management requires comprehension of natural processes and systemic interdependencies.

Dr. (Cdr.) Arnab Das contextualised these insights within the broader UDA Framework, emphasising the relevance of acoustic capacity-building, marine spatial planning, and inter-agency partnerships in addressing governance and sustainability challenges. The workshop concluded with certificate distribution and feedback sessions, during which participants expressed strong appreciation for the opportunity to engage with ground realities and affirmed the importance of such field-based capacity-building.

Overall, Day 3 successfully translated classroom learning into applied environmental understanding and strengthened participants' ability to contribute to national UDA initiatives with a more evident appreciation of ecosystem complexity and stakeholder integration.

Technology Intervention Highlights

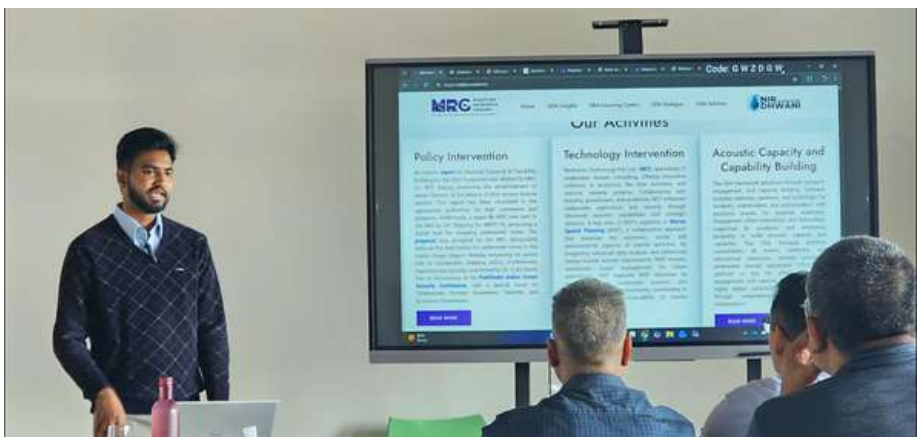
A key component of the 3-day UDA Workshop was the demonstration of advanced research and technology tools developed at our Centre to support decision-making across national security, blue economy development, environmental protection, and scientific innovation. These sessions showcased practical applications of UDA-driven solutions that multiple government agencies can leverage to enhance governance and operational efficiency.

One of the significant technologies introduced was the Shipping Radiated Noise (SRN) Estimation Tool, designed to map underwater noise generated from vessel traffic. The tool supports environmental assessments by identifying high-noise zones that may impact marine mammals and fisheries. It can also assist regulatory agencies in designing noise-sensitive maritime policies and sustainable port operations while ensuring safer navigation and surveillance. The capability to model acoustic footprint reduction with quieter ship designs was also highlighted as an essential future focus.

To strengthen sustainable blue economy planning, the session also covered the Marine Spatial Planning (MSP) Tool, which integrates ocean resource mapping, habitat sensitivity, and human activity zones into a unified decision-support framework. This tool will help reduce conflicts over ocean use among sectors such as fisheries, tourism, shipping, and energy development. By identifying suitable zones for development and conservation, MSP supports resilient coastal planning, long-term environmental stability, and enhanced socio-economic outcomes for coastal populations.

The officials were also introduced to the Area-Production-Yield (APY) Analysis Tool, which focuses on enhancing productivity from underwater living resources such as shrimp and seaweed. By analysing spatial, ecological, and production-related parameters, the tool enables stakeholders to optimise resource allocation, improve crop cycles, and maximise output in species such as shrimp, seaweed, and freshwater fish. Its scientific insights contribute to sustainable fish farming practices that safeguard aquatic ecosystems and uplift coastal and riverine livelihoods. Positioned as a key enabler of India's Blue Economy priorities, the APY Tool plays a transformative role in strengthening food security and creating long-term socio-economic impact for the fisheries community.

In addition to the individual tools, participants were briefed on major UDA Digital Platforms– UDA Digest, UDA Knowledge Center, UDA Learning Center and UDA Dialogue. These platforms offer a range of research resources, including articles, research notes, e-learning modules, and explanatory videos, on topics related to UDA, such as Blue Economy, Maritime Security, Digital Transformation, Sediment Management, and Climate Risk Assessment. The technology demonstrations reinforced the workshop's central message: indigenous UDA capabilities are essential for India's leadership in the Indian Ocean Region. The interactive discussions helped government officers understand how to incorporate these tools into their departmental mandates to strengthen underwater governance and drive sustainable development outcomes on the ground.



Impact Assessment

This UDA Workshop has delivered meaningful and measurable impact across institutional learning, cross-sector coordination, and future policy integration. The workshop successfully enabled participating officers to internalise the significance of the underwater domain as a national strategic asset that is critical to environmental governance, maritime sustainability, and socio-economic security. The progressive learning structure, combining conceptual grounding, technology demonstrations, and field exposure, ensured a clear understanding of how UDA translates into actionable benefits for tropical governance.

It enabled inter-agency collaboration: A notable achievement of this engagement was its emphasis on inter-agency collaboration. By bringing together officials from departments involved in forestry, national security, inland water systems, coastal regulation, biodiversity, and disaster management, the workshop helped break down knowledge silos that have historically limited cohesive decision-making. Participants gained new perspectives on the land–sea continuum, recognising that upstream interventions directly influence coastal erosion, aquatic biodiversity, and climate risk. This shift in perception will significantly strengthen coordination between environmental agencies and maritime stakeholders in future policy actions.

It will enable adoption of indigenous technologies: The technology intervention sessions created strong awareness about the role of indigenous digital solutions, such as MSP, SRN mapping, and APY tools, in enabling evidence-based planning and operational efficiency. Officers demonstrated a clear interest in adopting these platforms to support zoning regulations, environmental mitigation plans, aquaculture optimisation, and eco-sensitive infrastructure development. The workshop has therefore laid the foundation for integrating UDA-driven tools into departmental workflows, strengthening India's efforts to transform maritime governance digitally.

Capacity Building for UDA: The capacity-building outcomes were equally impactful. Through expert interactions and field-based learning, officers developed a deeper understanding of underwater sensing, acoustic behaviour, sediment dynamics, and the functioning of tropical aquatic ecosystems. The engagement reinforced the need for trained human capital to sustain emerging Blue Economy priorities. Many participants expressed intent to promote UDA knowledge sharing within their respective regions, ensuring the multiplier effects of this training continue to grow. The field visit on Day 3 provided a powerful real-world reflection on conservation–livelihood linkages. This experience strengthened appreciation of UDA as a human-centric framework that safeguards frontline populations while conserving critical ecosystems.

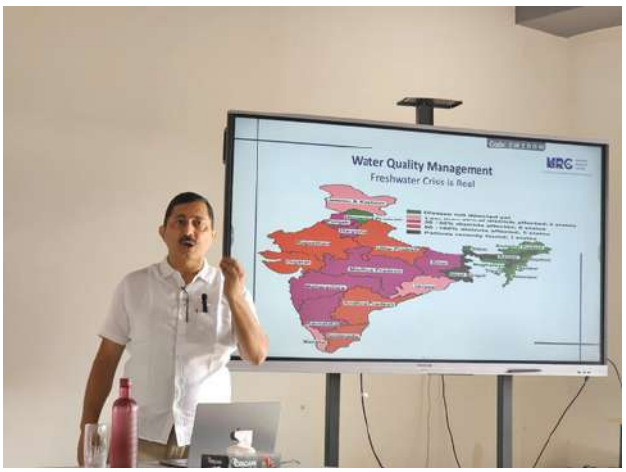
Overall, the workshop has enhanced national preparedness to address underwater challenges by improving awareness, strengthening institutional capacity, and aligning stakeholders. The outcomes indicate clear potential for mainstreaming UDA into national programs for river rejuvenation, digital transformation, climate resilience, and sustainable coastal development. **The learnings gained are expected to inform operational planning, encourage adoption of technological interventions, and promote proactive participation in the UDA journey across government systems.** The workshop has therefore made a significant contribution toward advancing India's leadership in tropical underwater governance and strengthening its long-term vision for a resilient and thriving Blue Economy.

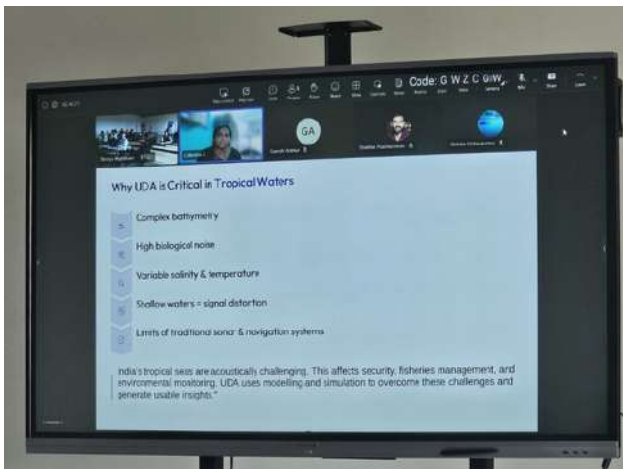
Recommendations and Way Forward:

To sustain the momentum generated through this capacity and capability-building initiative, the following recommendations are proposed for structured national adoption of the UDA framework:

1. Embed UDA principles into relevant ministries and state environmental agencies to strengthen coordination across underwater, freshwater, and marine ecosystems.
2. Establish inter-agency technical working groups to collectively address sediment movement, water quality, underwater noise, and coastal ecological risks.
3. Establish certification-based UDA skill development programs for officers, researchers, and ground staff.
4. Conduct state-level workshops to decentralise learning and build a wider government cohort.
5. Incorporate UDA knowledge into government training institutions to ensure continuity and scale.
6. Pilot and progressively implement indigenous UDA technology solutions (e.g., MSP Tool, APY Tool, SRN Mapping) across coastal and riverine states.
7. Facilitate the integration of departmental data to improve decision support and transparent governance.
8. Promote multi-disciplinary research collaborations linking acoustics, oceanography, ecology, and community sciences.
9. Mainstream local and indigenous community participation in planning and monitoring of aquatic ecosystems.
10. Recognise traditional knowledge as a validated input to data-driven governance models.

Image Gallery:





Annexture-1

Underwater Domain Awareness (UDA) Framework

Dr (Cdr) Arnab Das

The concept of Underwater Domain Awareness (UDA), in a more specific sense, will translate to our eagerness to know what is happening in the underwater realm of our maritime areas and the freshwater systems. This keenness for underwater awareness from the security perspective means defending our Sea Lines of Communication (SLOC), coastal waters, and varied maritime assets against the proliferation of submarines and mine capabilities intended to limit access to the seas and littoral waters. The freshwater systems, particularly the transboundary Rivers, are not defended by the Navy & the Coast Guard, but these waters are equally vulnerable and more complex to manage. However, military requirements may not be the only motivation for generating underwater domain awareness. The earth's underwater geophysical activities have a lot of relevance to the well-being of humankind, and monitoring them could provide vital clues to minimize the impact of devastating natural calamities. The commercial activities in the underwater realm need precise inputs on the availability of resources to effectively and efficiently explore and exploit them for economic gains. Underwater resources include fisheries, aquaculture, seaweeds, pharma ingredients, minerals, and others with significant market value. The regulators, on the other hand, need to know the pattern of exploitation to manage a sustainable plan. The connectivity through the water bodies has been recognized as the most effective and efficient mode of transportation, however, ensuring navigability in these water bodies requires a massive amount of UDA. With so many commercial and military activities, there is a significant impact on the environment. Any conservation initiative needs to precisely estimate the habitat degradation and species vulnerability caused by these activities and assess the ecosystem status and climate change risk. The scientific and research community needs to engage and continuously update our knowledge and access of the multiple aspects of the underwater domain. The global community is looking at the Indo-Pacific strategic space for their geopolitical and geostrategic engagements. The Indo-Pacific region, by definition, is the tropical waters of the Indian and Pacific Oceans. The tropical waters present unique challenges and opportunities regarding rich biodiversity and resource availability. However, the sub-optimal sonar performance is the biggest issue, limiting the UDA in these regions. The sonars that were designed for the temperate & polar waters of the Greenland, Iceland, United Kingdom (GIUK) gap during the Cold War era suffered 60% degradation when deployed in tropical waters. The developing nations in tropical waters need to customize these technologies to suit their conditions. The Western nations that are pushing this hardware do not have the manpower to deploy it. In contrast, the tropical nations, have the manpower but lack the appreciation of the technology and the know-how. The proposed UDA Framework, presented in the figure below, can optimize resource deployment and provide nuanced policy and technology intervention, along with acoustic capacity & capability building to manage the tropical challenges and opportunities. There is significant fragmentation among all four stakeholders, namely Strategic Security, Blue Economy, Sustainability & Climate Change Risk Management, and Science & Technology (Digital Transformation), and the UDA framework provides a comprehensive way forward for the stakeholders to engage and interact.

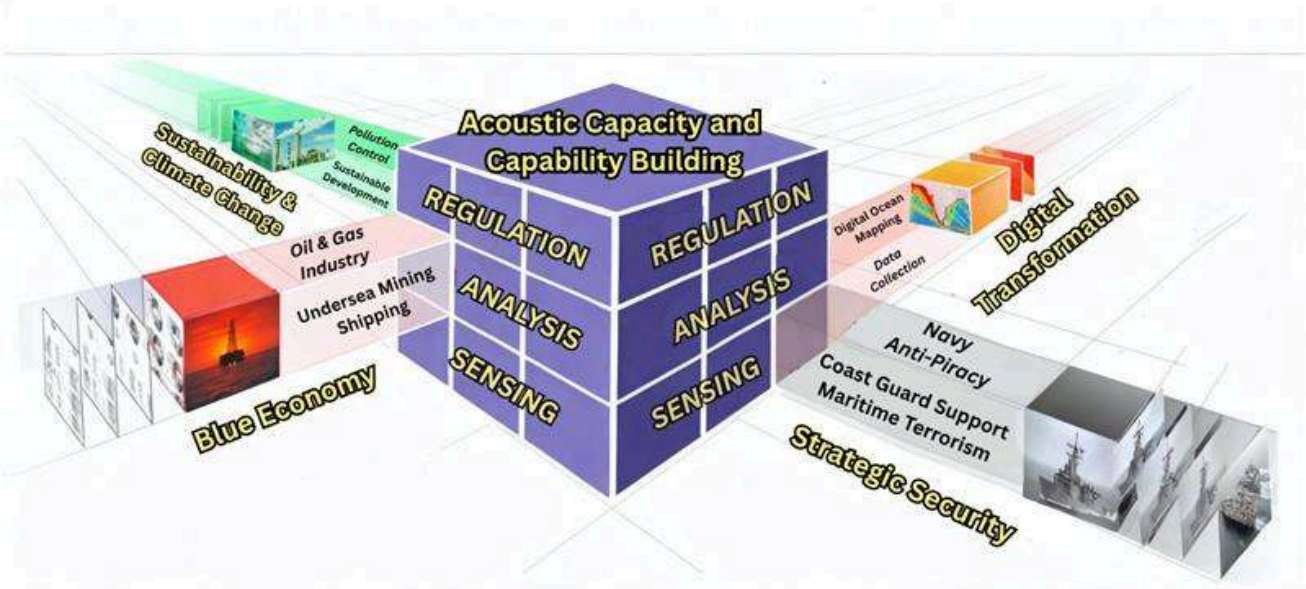


Figure. Comprehensive Perspective of the UDA Framework

On a comprehensive scale, the UDA Framework needs to be understood in terms of its horizontal and vertical construct. The horizontal construct would be the resource availability in terms of technology, infrastructure, capability, and capacity specific to the stakeholders or otherwise. The stakeholders represented by the four faces of the cube will have their specific requirements, however, the core will remain the acoustic capacity and capability. The vertical construct is the hierarchy of establishing a comprehensive UDA. The first level, or the ground level, would be the sensing of the underwater domain for threats, resources, and activities. The second level would be making sense of the data generated to plan security, conservation, and resource utilization strategies. The next level would be to formulate and monitor regulatory framework at the local, national, and global levels. The individual cubes represent specific aspects that need to be addressed. The 'User-Academia-Industry' partnership can be seamlessly formulated based on the user requirement, academic inputs, and the industry interface represented by the specific cube. It will enable a more focused approach and a well-defined interactive framework. Given the appropriate impetus, the UDA Framework can address multiple challenges being faced by the global community today. Meaningful engagement of the young and aspirational population is probably the most critical aspect that deserves attention. Multi-disciplinary and multi-functional entities can interact and contribute to synergize their efforts towards a larger goal seamlessly.

The UDA Framework is a structured, comprehensive, and inclusive framework to drive the underwater domain effectively and efficiently. The structured approach will minimize the fragmentation among the stakeholders, regional players, national authorities, and local bodies. The multiple entities will have divergent interests and priorities, thus, converging them into one single and focused governance mechanism will be a challenge. The governance mechanism must be comprehensive and recognize all dimensions of the stakeholder requirement. The dimensions include varied layers that are instrumental in building a strong governance mechanism. The first layer would be five pillars: research, skilling, academia, innovation, and policy.

The second layer is its translation into policy & technology intervention, along with acoustic capacity & capability building. The inclusive aspects include varied socio-economic, socio-political, and socio-cultural native groups in the larger governance framework. The varied socio-economic strata of the society, particularly the coastal & riverine communities, get excluded in the conventional development models. The students need to prepare for real-world challenges and get very late before they get exposed to the nuances of real-world issues. The political spectrum is always driven by the social structure, based on left or right leanings. The governance mechanism has to address the concerns and aspirations of both sides. The cultural divide translates to the traditional practices and beliefs that drive their livelihoods and social structure. The governance mechanism has to address these divides and integrate everyone into one national, regional, or global framework.

The global community is also professing the triad of people, economy, and nature for enhanced governance mechanisms. The people component includes the livelihood, well-being of the native communities, social dynamics, and more. The economic component is the growth and prosperity associated with the activities. The nature component addresses sustainability and climate change risk management. This is also measured in terms of the Environmental, Social, and Governance (ESG) formulation. The UDA Framework is consciously addressing all these varied measures of global good parameters.

Annexture-2

Important Videos :

S. No.	Speaker	Session Topics	QR Code
		Day 1- Sessions	
1.	Dr. (Cdr) Arnab Das, Founder and Director, MRC	Underwater Domain Awareness (UDA) as an Environmental Imperative	
2.	Cathrine J, Head of Research and Publications, MRC	Blue Economy and Marine Spatial Planning (MSP): Policy Interventions through a UDA Lens	
3.	Shridhar Prabhuraman, Deputy Director, MRC	AI-Driven Modelling & Simulation-based Marine Spatial Planning: A Strategic Approach for India in the Indian Ocean Region	
4.	Cathrine J, Head of Research and Publications, MRC	MSP Handbook and Policy Frameworks for Forest and Coastal Governance	
5.	Nishtha Vishwakarma, Head of Communication and Outreach, MRC	Implementation of the UDA Framework through the ' '100 Warriors' initiative	
6.	Ayush Sawadh, Research Engineer, MRC	MRC's Body of Work: Translating UDA Research into Environmental Impact	

		Day 2- Sessions	
1.	Dr. (Cdr) Arnab Das, Founder and Director, MRC	Enabling UDA Operations: Infrastructure, Technology, and Policy Framework for Autonomous Underwater Systems	
2.	Romit Kaware, MRC Research Fellow	UDA-Based Sediment Management in the Tropical Indo-Pacific	
3.	Professor Mimi Fabe, MRC Research Fellow	Integrating ASEAN heritage with Underwater Domain Awareness for regional water security and resilience	
4.	Andrea Toledo, MRC Research Fellow	Empowering Indigenous Sea Communities	
5.	Jay Pinjarkar, Research Engineer, MRC	MSP and SRN Tool Demos	
		Feedback Sessions	
1.	Participants of the UDA Workshop	Feedback Session (Day 1)	
2.	Participants of the UDA Workshop	Feedback Session (Day 2)	

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