

Case Studies

Resolving Real-world issues through the UDA Framework

India is on its path to glory, and the global community does recognise our potential to contribute towards a better world order. Geopolitically and geo-strategically, we are definitely making the right kind of moves to ensure our status as a global power. Recently, we have also started recognising our maritime status, and the blue economy is getting the importance it deserves. A nation with over 7,500 km of coastline and a vast network of freshwater systems has to prioritise Underwater Domain Awareness (UDA) to ensure effective governance mechanisms across these water bodies and beyond. India's Exclusive Economic Zone (EEZ) comprises more than 3.4 million square kilometres; however, the contribution of the maritime domain to the GDP is only 4%. The massive rush towards a blue economy has to also be backed by serious policy interventions that are able to ensure sustainability and minimal climate change risk. The geopolitical status of the Indian Ocean Region (IOR) also means significant political volatility, resulting in serious strategic security concerns. Thus, UDA has to be multi-dimensional and should be able to address the challenges and opportunities of all four stakeholders, namely strategic security, the blue economy, sustainability and climate change, and digital transformation.

The UDA in tropical waters has to deal with the suboptimal performance of the sonars. The degradation in sonar performance is of the order of 60% compared to temperate or polar waters, where they were originally designed and developed. Thus, indigenous and site-specific R&D with field experimental validation is extremely critical. The UDA framework needs to address policy intervention, technology intervention, and acoustic capacity and capability building across the four stakeholders. Digital transformation is the only way forward to ensure good governance, and its manifestation will be in the form of marine spatial planning (MSP). MSP is being prioritised by the United Nations's (UN) and Intergovernmental Ocean Commission's (IOC) as their main agenda under the Decade of Ocean Sciences for Sustainable Development programme.

The Maritime Research Centre (MRC) and M/S Nir Dhvani Technology Pvt. Ltd. (NDT) have proposed a UDA framework as shown in Enclosure 1. It encourages pooling of resources and synergizing of efforts across the stakeholders to optimise resource deployment. The spatio-temporal mapping of threats and resources for MSP can be effectively driven by the UDA framework. The UDA framework addresses the challenges and opportunities of the marine and freshwater systems while seamlessly recognising their tropical characteristics. The tropical issues are spread across varied applications, ranging from fisheries, aquaculture, mineral resources, freshwater resource management, freshwater quality management, urban flooding, the blue economy, strategic security, and many more. It has to be a mix of socio-economic,

socio-political, and socio-cultural efforts to manage these mammoth activities. A good governance mechanism will require a nuanced approach.

Proposal

Policymakers and stakeholders across the spectrum need to be sensitised to the specific gaps in the governance mechanism to address these issues. The socio-economic, socio-political, and socio-cultural dynamics also need to be articulated for a nuanced policy intervention. The policy intervention has to be backed by an efficient and viable technology intervention. To make it all happen seamlessly, a multi-disciplinary and multi-functional capacity-building initiative is inescapable. Acoustics, being the only means to see below the surface of the water, mandates that acoustic capacity and capability building have to be prioritized. Traditional knowledge and traditional practices need to be mapped with modern tools to build an effective governance mechanism. This concept note comprises multiple case studies to address the gaps spread across multiple dimensions. The case studies will be presented using varied means, including e-learning modules (accessible from our own in-house platform, **UDA Learning Centre**), articles in multiple textual formats (accessible from our own in-house platform, **UDA Digest**), research notes and innovation notes (accessible from our own in-house platform, **UDA Knowledge Centre**), and an audio-video repository of panel discussions and expert interactions (accessible from our own in-house platform, **UDA Dialogues**). Every identified gap will be presented using multiple means, as listed above, to sensitise the participant effectively.

Case Studies

The case studies will comprise the following ten modules to start with, and many more will be progressively added to the list. The UDA framework will comprehensively, inclusively, and in a structured manner enhance our appreciation of the underwater space to facilitate good governance. The interconnectedness of various dimensions—socio-economic, socio-political, and socio-cultural aspects—and geopolitical and geostrategic aspects will be seamlessly addressed.

Freshwater Management

The escalating population and rapid and unplanned urbanisation in India are significantly straining freshwater resources and quality management. The country faces a 20% water shortage, projected to rise to 80% in the next decade if current trends persist. Key issues include plastic waste, toxic discharges from industries, untreated sewage, solid waste, unregulated agricultural practices, and mining activities, all of which severely degrade water quality. Floods, droughts, groundwater depletion, wetland loss, siltation in lakes and reservoirs, urban flooding, ecosystem degradation, and climate change impacts further complicate freshwater management. Tropical siltation patterns exacerbate sediment management challenges, affecting

storage capacity and dam safety. To address these issues comprehensively, an integrated freshwater management framework is essential. This should include real-time monitoring, stricter pollution control regulations, modern waste treatment systems, public education on water conservation, sustainable agricultural practices, and efforts to clean and rehabilitate polluted water bodies. The following modules will be included:

- Water Resource Management
- Water Quality Management
- Fisheries and Aquaculture
- Inland water transport
- Benthic Ecosystem Management
- Sediment Transport Study
- Sediment Bearing Pressure
- Impact of Climate Change
- Livelihood Opportunities
- Digital Transformation

Inland water transport

Inland Water Transportation (IWT) is an inter-modal transportation initiative for moving goods and passengers. There are 14,500 km of navigable waterways in India. Out of these, about 5,700 km are navigable by mechanised vessels. IWT refers to the movement of goods and people using navigable rivers, canals, and other inland waterways. It is an efficient, cost-effective, and environmentally friendly mode of transportation, particularly suitable for bulk goods and heavy cargo over long distances. It will decongest rail and road transportation and bring massive efficiency in logistics and connectivity. IWT often complements other transport modes like road and rail, contributing to a more integrated and sustainable transport network. However, in the tropical region, sediment management is an extremely complicated issue, and the unique siltation needs to be addressed effectively. The rich biodiversity in the tropical waters also raises significant sustainability concerns. The following modules will be included:

- Navigability in the Waterways
- Acoustic Habitat Degradation
- Sustainable Blue Economic Perspective
- Dredging and its nuances
- Sediment Transport Study
- Sediment Bearing Pressure
- Impact of Climate Change
- Benthic Ecosystem Management
- Sagarmala
- Digital Transformation

Coastal Management

It is a well-known fact that 80% of the global population resides within 200 km of the coast. Thus, coastal regions are critical for the development of human civilisation and economic growth. However, the human vs. nature and land vs. sea interface has its own complicated fallout that causes serious governance concerns. The abundant resources and the aspirational human population, in an attempt to maximise the gains, create long-term sustainability and climate change risk. The diversity of the coastal population and their equally diverse socio-economic, socio-political, and socio-cultural characteristics make it easy for corporations to exploit their natural resources. Mega-development projects like ports, mechanised fishing, tourism hubs, industrial-scale aquaculture, coastal transportation, strategic security projects, and more make it a vicious cycle where the native coastal populations get marginalized. The unique tropical characteristics often get ignored at a very high cost in our enthusiasm to embrace western technology and know-how. The following modules will be included:

- Sediment Management
- Livelihood Opportunities
- Transportation and Connectivity
- Abiotic Content Management
- Sediment Bearing Pressure
- Blue Economic Perspective
- Acoustic Habitat Degradation
- Fisheries and Aquaculture
- Climate Change Impact
- Digital Transformation

Port Management

Ports are essential hubs that connect maritime transport with other modes of transport, driving economic growth through trading, distribution, and logistics activities. They vary widely in scale and complexity, from small quays to large industrial centers. The tropical waters present unique challenges in port management related to ensuring navigability, sustainability, climate change risk resilience, coastal community interface, strategic security, operational cost effectiveness, and more. Capacity and capability building is a serious challenge, given the overdependence on western technologies and know-how. The recent realisation of our maritime potential has made for a massive push towards maritime capacity and capability building; however, the nuanced way forward is critical given sustainability and climate change risk concerns. The following modules are included:

- Sediment Management
- Sagarmala
- Benthic Ecosystem Management
- Sediment Bearing Pressure
- Sediment Transport Study

- Dredging and its nuances
- Blue Economic Perspective
- Acoustic Habitat Degradation
- Climate Change Impact
- Digital Transformation

Community Engagement

The coastal communities, particularly in the Indian Ocean Region (IOR), have been part of the civilizational legacy for over 10,000 years. Traditional practices and knowledge are most aligned with tropical characteristics and can be a game changer for sustainability and climate change risk management. However, these communities often get economically, socially, and politically marginalised due to their limitations in dominating the political narrative. These native communities often become the victims of development, whereas they should be the beneficiaries. The youth of these communities lack skills and knowledge of modern tools to be part of the mainstream narrative. The governance mechanism lacks the framework to integrate traditional knowledge and practices into the development process. Policymakers also lack the understanding of the tropical characteristics to reap benefits due to their overdependence on western inputs. The following modules have been included:

- Livelihood Opportunities
- Fisheries and Aquaculture
- Blue Economic Perspective
- Sediment Management
- Seaweed Cultivation
- Extreme weather events
- Importance of the Underwater Domain
- Underwater Domain Awareness (UDA) Framework
- Climate Change Impact
- Digital Transformation

Strategic Security

The IOR has become extremely volatile politically due to the fragmented geopolitics of the region. The non-state actors are operating with ease and with the covert support of the nation-states and extra-regional powers. The disruptive means available with these non-state elements are a serious concern and cannot be countered with the traditional security apparatus. It may be said that our maritime forces, namely the navy and the Coast Guard, are specialised in maritime conflicts against well-defined external forces; however, the paramilitary forces deployed for internal security need significant capacity and capability building to counter the emerging underwater threats. The marine police and the other paramilitary forces deployed for water front security across the coast and the transboundary rivers and other water fronts need state-of-the-art surveillance appreciation to monitor the vast areas under their mandate. The tropical limitations in

the IOR need specialised acoustic capacity and capability building. The strategic security challenges may vary from outright sabotage of freshwater systems to severe environmental and climate change degradation leading to food and energy security breakdowns. A shortage of clean freshwater for domestic consumption could lead to communal tension and social disharmony. Loss of livelihood due to disruption in available water resources for agriculture, fisheries, aquaculture, and many more can be a cause for serious concern. Disruption of safe navigable waters for inland water transport could be another internal security challenge. Modelling and simulation are critical to predicting such possibilities and institutionalising mitigation action. The following modules have been included:

- Maritime Domain Awareness (MDA)
- Tropical Characteristics
- Capacity and Capability Building
- UDA Framework
- Non-Traditional Threats
- Undersea Cables
- Piracy and terrorism
- Narcotics and Smuggling of Banned Items
- Climate Change Impact
- Digital Transformation

Environmental, Social, and Governance (ESG)

The global community has started realising the seriousness of sustainability and climate change risks. Institutionalised efforts to manage these concerns are important so that we are able to comprehensively and inclusively address them. A structured approach that addresses policy and technology interventions along with capacity and capability building will be extremely critical. Environmental, Social, and Governance (ESG) has become the key framework to manage these concerns. Given that the planet is 75% water and that more than 95% of the threats and opportunities reside below the surface, the Underwater Domain Awareness (UDA) has to be prioritised for ESG realization. On top of that, the unique tropical characteristics have to be front-loaded in any ESG assessment and implementation. The objectivity of the ESG realisation can be achieved by implementing digital transformation backed by the UDA framework. The following modules have been included:

- ESG in general
- ESG Assessment and Formalisation
- People, economy, and nature
- Livelihood: Challenges and Opportunities
- Community Engagement
- Acoustic Habitat Degradation
- Climate Change Impact
- Sustainable Blue Economy Perspective
- UDA framework
- Digital Transformation

Livelihood

The global population is on the rise, and thus the pressures on natural resources and livelihood opportunities are extremely strained. The tropical waters boast rich biodiversity and high undersea mineral resources; however, we notice very little contribution of the ocean resources to the Gross Domestic Product (GDP). We are largely the victims of sustainability concerns and climate change risk. The aggressive corporate push has marginalised traditional practices and livelihood opportunities. The coastal and riverine communities are not agile enough to prepare themselves for the new opportunities. Their knowledge of the trends is also limited to being prepared for the new global order. A comprehensive, inclusive, and structured way forward is critical to generating livelihoods for the coastal and riverine communities and

minimising migrations. These youths have to be skilled and impart knowledge to navigate a sustainable and climate change-resilient development process. The following modules have been included:

- Livelihood: Challenges and Opportunities
- Traditional Livelihood and the Changing Landscape
- 100 Water Warriors
- 100 Coastal Warriors
- 100 River Warriors
- Skilling Ecosystem
- Digital Transformation and Livelihood Landscape
- Underwater Domain Awareness (UDA)
- UDA Framework
- Climate Change Impact
- Blue Economic Perspective

The Tyranny of Small Decisions and the Tyranny of Commons

Decision-making for policy formulation with long time frames and a large geographical expanse often suffers from the tyranny of small decisions. Policymakers have to deal with massive diversity and ensure fairness across varied stakeholders. They also face limitations in terms of resources, mandate, jurisdiction, aspirations of the people, and more. Many times, seemingly rational decisions, when combined across time and space, have unfavourable outcomes with massive negative impacts. Predicting such outcomes is extremely important to ensure effective governance. Tyranny of the commons is another such policy-making challenge where shared resources get overexploited, resulting in massive sustainability concerns and climate change risk. The population explosion across the globe, and particularly in the tropical regions, needs to be dealt with in a nuanced manner. The rapid development and aspirational young population need to be managed appropriately to ensure equity in access to natural resources. The following modules will be included:

- The Tyranny of Small Decisions
- Tyranny of Commons
- Case Studies
- Acoustic Habitat Degradation
- Overfishing
- Coastal communities vs. development
- Urban Flooding
- Freshwater management
- Groundwater Mismanagement
- Traditional Practices vs. Development

Acoustic Capacity and Capability Building

We are aware that 75% of the earth is water, including marine and freshwater systems. Out of these, it is safe to assume that 95% of the threats and resources lie beneath the surface of the water. Further, it is important to appreciate that the acoustic survey using sonars is the fundamental tool for any attempt at underwater domain awareness (UDA). The global community made massive strides in UDA during the Cold War Era, primarily driven by their strategic security requirements. The Western Block, led by the US, and the Eastern Block, led by the USSR, invested heavily in underwater technology and achieved significant progress in sonar systems. However, their theatre of engagement was in the Greenland, Iceland, and United Kingdom (GIUK) gap, which is the temperate and polar region. In the 21st century, the theatre of engagement has shifted to the tropical waters of the Indo-Pacific region. It is known that the sonar performance degrades in tropical waters by close to 60%; thus, acoustic capacity and capability building need to be prioritised for good governance. The following modules have been included:

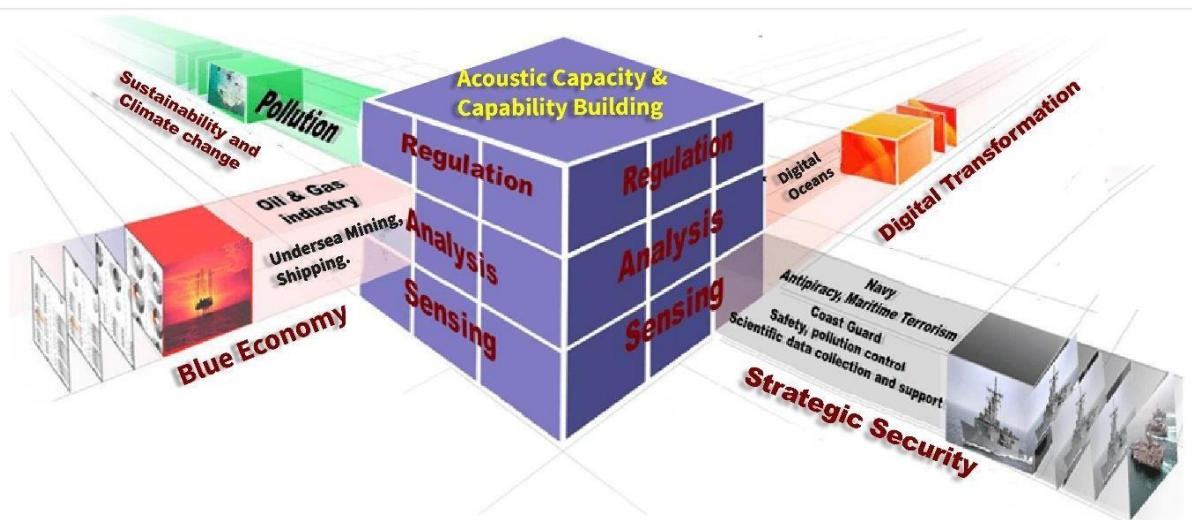
- Tropical Characteristics
- Comprehensive, structured, and inclusive
- Research, Innovation, Skilling, Knowledge, and Strategy
- Source-Path-Receiver Model
- Modelling and Simulations (M&S)
- Livelihood
- Strategic Security Perspective
- Sustainable Blue Economy
- Climate change risk management
- Digital Transformation

Enclosure-1

Underwater Domain Awareness (UDA) Framework

The universe is 75% water, including 5% freshwater comprising of the ice cover and it is such an important component for human survival and prosperity. Management of the underwater domain will open up an unimaginable scale of opportunity for economic prosperity and ecological balance. Sustainable Blue Economy, Climate Change Risk Management, Strategic Security, Digital Transformation, Freshwater Management, Energy Security, Food Security and many such aspects have a direct relevance to the Underwater Domain. Underwater Domain Awareness (UDA), is thus a critical first step towards management of this new frontier of human endeavor.

The 21st century saw a significant focus on the Maritime Domain Awareness (MDA), post the 9/11 globally and the 26/11 episode in the Indian Ocean Region (IOR). However, the MDA remained security driven and couldn't penetrate below the surface. The [UDA framework](#), proposed by the [Maritime Research Center \(MRC\)](#), and [M/S NirDhwani Technology Pvt Ltd \(NDT\)](#), is a structured, comprehensive and inclusive concept. It will address the challenges & opportunities of the four stakeholders, as shown in the figure below:



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The UDA framework is supported on five pillars, namely research, skilling, academia, innovation and strategy. The MRC and NDT has endeavoured to progress all these five dimensions with equal vigour and made significant contribution to each one of them as presented in our [Annual Report](#). The intellectual contributions have also been well documented to make sure there is enough body of work available for the future generations as presented in our in-house platform named [UDA Digest](#), [UDA Learning Center](#), [UDA Dialogue](#) and the [UDA Knowledge Center](#).

The [tropical waters](#) of the Indo-Pacific strategic space present unique characteristics and thus the UDA for these waters require indigenous efforts of an unprecedented scale with field experimental validations. The innovative projects undertaken by [NDT](#) and the acoustic signal processing expertise can contain the impact of the tropical waters. The NDT offers detailed support across the strategic security and sustainable blue economy dimensions. NDT offers consultancy, solutions, innovation support, turnkey project execution including field deployments, data handling and more.

The [Digital Transformation](#) has become a buzzword and the maritime community is referring to it as [Marine Spatial Planning \(MSP\)](#). NDT has developed unique MSP capabilities to serve the entire marine and freshwater applications. The proposed MSP formulation is unique in terms of its cost efficiency and broad effectiveness across the stakeholders. The tropical challenges are very well addressed and also the high innovation level makes it user friendly.

The UDA framework ensures nuanced policy & technology interventions along with [Acoustic Capacity & Capability building](#) for safe, secure, sustainable growth for all in the tropical waters of the Indo-Pacific strategic space. The pooling of resources and synergizing of efforts will optimize resource deployment and encourage broader participation by the global south. MRC & NDT is working with partners to establish [Center of Excellence](#) across the world with multilateral and bilateral partners.

Join us in this exciting journey to be part of the emerging [Ocean of Opportunities](#) across the stakeholders. The [young students and professionals](#) can seek new possibilities and also the [corporates](#) can be part of the new global order.

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