Title: Mapping the Indian ocean rim association through the underwater domain awareness framework: Pillars, challenges, opportunities for digital transformation and the way forward

Abstract: The Indian Ocean Rim Association, a dynamic intergovernmental organization with its 23 member states and 11 dialogue partners, is dedicated to promoting regional cooperation. The Indian Ocean region has both strategic and economic advantages, but still, problems related to security, environmental degradation and sustainable development are huge issues. This research note critically examines IORA's six key areas through the Underwater Domain Awareness (UDA) framework, challenges faced by IORA from socio-economic, socio-political and socio-cultural factors and demonstrates how digital transformation and maritime spatial planning can promote resilience and integration. The UDA framework allows researchers to examine the multilayered complexity of the region through its informational and policy dimensions. This research note suggests that integrating UDA into IORA's strategic planning will lead to better regional cooperation alongside increased security measures.

Keywords: Indian Ocean Rim Association, Underwater Domain Awareness, Digital Transformation, Maritime Spatial Planning, Maritime Security.

Introduction

The Indian Ocean Region (IOR) plays a crucial role in strategic operations while providing essential economic benefits and environmental relevance. The Indo-Pacific region experiences transformative geopolitical changes, which elevate the Indian Ocean to a dual-purpose stage for both cooperation and rivalry. The Indian Ocean Rim Association (IORA), formed in 1997, works to establish fair economic growth and integrate regional economies. Approximately 2.7 billion residents of IORA member states, together with 90% of worldwide trade shipped through maritime routes, create the main economic pathway globally. The Indian Ocean faces operational limitations because of ongoing problems, which include maritime insecurity, together with ecological vulnerability and insufficient integrated data structures. (Indian Ocean Rim Association, 2025)

The Underwater Domain Awareness (UDA) framework addresses these issues holistically by focussing on gaining a thorough grasp of the underwater environment. This research note analyses how the strategic pillars of IORA connect with the UDA framework to boost regional cooperation and resilience.

The Underwater Domain Awareness (UDA) framework presents a solution that combines oceanographic information with acoustic monitoring systems and coordinated decision models. This framework applied to IORA enables alternate interpretations of both regional capacity deficiencies and future developmental possibilities. (Underwater Domain Awareness (UDA) framework, 2020)

This research note is aimed to analyse IORA's essential mechanisms together with strategic foundations under the UDA framework, which will identify existing problems as well as future modifications.

The Indian Ocean Rim Association (IORA) objective is to foster regional relationships and sustainable development across Indian Ocean countries. The following are the six pillars that define IORA:

- 1. Maritime Safety and Security
- 2. Trade and Investment Facilitation
- 3. Fisheries Management
- 4. Disaster Risk Management
- 5. Academic, Science and Technology Cooperation
- 6. Tourism and Cultural Exchanges

The member states work to integrate their policies and practices through these pillars however; they face obstacles due to different national objectives and capabilities. (Indian Ocean Rim Association (IORA), 2024)

Challenges Facing IORA

1. Legal and regulatory gaps

The legal and marine enforcement capabilities of IORA nations differ greatly. While some jurisdictions lack the fundamental laws necessary to control Exclusive Economic Zones (EEZs) or enforce Marine Protected Areas (MPAs), others have strong marine laws that are in line with UNCLOS and ILO treaties. Various countries need to develop fundamental legal structures that regulate Exclusive Economic Zones (EEZs) together with Marine Protected Areas (MPAs). Smaller island nations experience difficulties because their maritime domain enforcement agencies do not have sufficient ships, personnel resources and real-time domain awareness capability. (Rai, 2025) Unclear legal boundaries create disputes about maritime territories and resource management that prevent regional cooperation.

2. Economic factors

A large number of IORA member states lack strong institutions and economies. The only developed countries in the category are Singapore and Australia. These limitations hinder the effective execution of decisions, particularly those concerning economic unification. The lack of self- funding will create challenges for the organization to maintain financial independence. (Waidyatilake, 2017)

3. Public Awareness

The successful execution of waste management policies and objectives depends on the active involvement of the general population. The main goal of these policies involves promoting better education while developing understanding and creating stronger commitment to environmental initiatives. The public's lack of interest in marine concerns outside of the fishing industry results in decreasing political pressure for reforming environmental management. (Liu et al., 2023)

4. Human and Natural Environmental Threats

The combined effects of coastal industries and untreated sewage, along with ship discharge and offshore drilling operations, produce extensive marine pollution. The IORA region has recently published multiple reports that display concerning levels of microplastic contamination present in fish populations, mangroves and coral reefs. Coastal communities face displacement as a result of rising sea temperatures, coral bleaching and saltwater intrusion combined with stronger cyclones that endanger wildlife populations. (Biswas & Pal, 2023)

5. Insufficient Investments and Infrastructure

Many ports throughout Eastern Africa and island states, together with those in the region, suffer from outdated and unproductive facilities, which create congestion problems. The lack of dry-docking facilities creates a major obstacle which prevents foreign shipping companies from using these facilities. The absence of regular funding causes navigation equipment, underwater cables, buoys, and maritime surveillance systems to deteriorate. Investment in ocean technology, marine biotechnology, sustainable offshore energy and aquaculture remains at low levels in spite of official commitments to the blue economy. (Final Report, 2023)

The UDA Framework

The UDA framework focuses on complete comprehension of underwater environments through its integration of maritime security and environmental monitoring together with resource management. The framework promotes a multi-stakeholder model which combines governmental bodies with academic institutions and private sector organizations and civil groups for maritime domain awareness and decision-making improvement. The UDA framework operates on four main elements which are:

• Security functions as the main action for monitoring maritime boundaries and protecting vital infrastructure.

• The framework supports environmental sustainability by conducting assessments and implementing measures to reduce human activity effects on marine ecosystems.

• The framework enables sustainable resource use through its methods for underwater resource exploitation.

• Disaster Preparedness systems in the framework aim to enhance early disaster warnings and response strategies for natural events.

(Underwater Domain Awareness (UDA) framework, 2020)

Mapping IORA's Strategic Pillars to the UDA Framework

1. Maritime Safety and Security

The UDA framework works together with IORA's maritime security targets to gather realtime data on underwater threat strengthens surveillance operations and improves coordinated incident responses. UDA implementation produces better regional security through enhanced maritime domain awareness and united security measures. (Iyer, 2020)

2. Trade and Investment Facilitation

The UDA system provides extensive knowledge about underwater landforms and navigational risks that make maritime trade routes safer and more efficient. The data serves as essential information for building ports and maintaining infrastructure which results in investment attraction and economic enhancement. (Iyer, 2020)

3. Fisheries Management

Through UDA technology scientists can conduct precise monitoring of fish populations and underwater habitats which leads to effective fisheries management. The underwater ecosystem data supports the implementation of conservation strategies and enforcement against IUU fishing operations. (Tripathi, 2024)

4. Disaster Risk Management

The UDA framework improves disaster readiness through its provision of warning systems for earthquakes and underwater tremors. UDA enables better infrastructure development and evacuation planning to minimize natural disasters effects on coastal populations. (UDA framework, 2024)

5. Academic and Scientific Cooperation

Through UDA programs, IORA members establish partnerships to develop research programs that enhance scientific knowledge and build marine science capabilities. researchers develop a better understanding of the underwater ecology in the Indian Ocean through the use of shared data platforms and cooperative research. (IORA Priority Areas, 2025)

6. Tourism and Cultural Exchanges

The UDA framework enables sustainable tourism growth through its work to protect underwater cultural heritage sites. The framework enables tourists to have immersive virtual diving experiences while simultaneously protecting delicate marine ecosystems. (Bruno et al., 2020)

Digital Transformation and Marine Spatial Planning

The implementation of digital technology plays a strategic role in improving both the UDA framework and IORA initiatives. Digital tools such as GIS and remote sensing enable Marine Spatial Planning (MSP) to develop systematic resource and activity allocation strategies. (Das, 2022) The combination of these methods enables fair development while protecting the environment and resolving conflicts among maritime stakeholders.

The implementation of digital transformation enables real-time data sharing and predictive analytics while supporting decision support systems, which become crucial for maritime governance to be proactive. The improvement of digital infrastructure, together with capacity building in IORA member states, will enable technological gap reduction and drive inclusive growth. (Das, 2022)

Limitations

The UDA implementation details within IORA member states face limitations because of insufficient specific data availability for research notes. The evaluation relies on literature that is accessible but does not cover all essential research because it excludes studies from non-English languages and less accessible journals. The technological capability differences between IORA member states might affect how well the proposed integration strategies can be applied.

Way Forward

To improve the integration of the Indian Ocean Rim Association's (IORA) strategic pillars with the Underwater Domain Awareness (UDA) framework, implementation of the following actions is required:

1. IORA should establish a Regional Centre of Excellence (CoE) for underwater domain awareness by dedicating it to UDA research and training, along with policy development. The centre will serve as a knowledge exchange platform to help member states develop their capacity for underwater domain awareness. (IORA Centre of Excellence, 2025)

2. The development of a standardized data sharing protocol will strengthen the collaboration between IORA members by building trust among them, which will lead to better maritime surveillance and resource management.

3. Allocation of resources to Digital Infrastructure: Member states should focus their resources on creating digital tools, including Geographic Information Systems (GIS) and remote sensing technologies, as they will enable Marine Spatial Planning (MSP) and related UDA operations.

4. PPPs should be supported through Public-Private Partnerships (PPPs) because these agreements enable private partners to fund technological developments needed for UDA advancement.

5. Traditional maritime knowledge combined with scientific approaches enhances UDA programs through better research quality and deeper community participation.

(The Hindu Op-ed: Charting a route for IORA under India's chairship, 2025)

Conclusion

The implementation of the Underwater Domain Awareness framework will greatly enhance IORA's potential to develop into a unified and proactively operational regional organization. The strategic and operational unification brought by UDA enables the resolution of current maritime governance challenges. This research note highlights that linking IORA pillars to UDA is both a logical concept and an immediate practical requirement.

The area surrounding the Indian Ocean holds great potential together with substantial obstacles. The Indian Ocean Rim Association demonstrates effective dialogue development but its effectiveness suffers due to unequal capability growth and policy discord.

In this research note it is argued that aligning IORA priorities with the Underwater Domain Awareness framework represents a powerful new direction. The holistic structure of UDA unites different stakeholders to increase regional readiness and connect scientific research to policy execution. The implementation of digital technology and Maritime Spatial Planning by IORA will enable both secure and sustainable development of its extensive blue territory.

The achievement of comprehensive security and prosperity in the Indian Ocean community demands the establishment of joint actions along with capability development and open policies.

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