

The Role of Standards in Maritime-Based Development: An Analysis of Challenges in Iran's Maritime Industry

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ABSTRACT

Maritime-based development has emerged as a critical pathway for achieving sustainable economic growth, particularly for coastal states whose industries depend on safe, efficient, and environmentally responsible maritime operations. Despite its strategic maritime position, Iran faces significant challenges in aligning its maritime sector with international standards. This study examines the role of technical, legal, and operational standards in shaping maritime-based development, with a focus on identifying structural barriers within Iran's maritime industry. Employing a comparative qualitative methodology, the research analyzes international benchmarks—including key IMO conventions such as SOLAS, MARPOL, and STCW—and compares them with Iran's existing regulatory framework, institutional capacities, and enforcement practices.

The findings reveal several critical gaps, including outdated regulatory instruments, weak and fragmented inspection mechanisms, insufficient adherence to IMO-mandated safety and environmental standards, and limited integration of global best practices in maritime education and training. Additionally, the study identifies institutional overlap and lack of inter-agency coordination as major obstacles to effective implementation. The research concludes that Iran can significantly enhance its maritime competitiveness by updating national regulations, strengthening port and vessel inspection systems, adopting a unified maritime governance structure, and fully harmonizing its educational programs with STCW requirements. These reforms are essential for enabling Iran to transition toward a modern, safe, and globally competitive maritime economy, thereby leveraging its maritime geography for sustainable national development.

Introduction

Maritime industries play a vital role in supporting global trade, energy security, and sustainable economic growth. Over 80 percent of the world's goods are transported by sea, making maritime safety, efficiency, and environmental protection

critical to international development [1]. In this context, technical and regulatory standards serve as the backbone of maritime operations, ensuring compliance, safety, and interoperability across borders. The International Maritime Organization (IMO) and other classification societies such as DNV, ABS, and ClassNK have developed a complex

framework of conventions and technical standards[15]including SOLAS, MARPOL, and STCW that define the parameters of modern maritime governance [2] , [3] [11].

In Iran, the maritime sector has immense potential due to its geographical position along the Persian Gulf, the Gulf of Oman, and the Caspian Sea. However, despite this strategic advantage, Iran's maritime industry faces persistent challenges in achieving global competitiveness. Several studies have identified issues such as outdated technical regulations, limited compliance with IMO conventions, weak inspection mechanisms, and inadequate integration of international standards into domestic law [4]. These shortcomings hinder the effective modernization of Iran's maritime infrastructure and reduce its ability to participate in the global blue economy.

This paper argues that updating and harmonizing Iran's maritime standards with international norms is essential for advancing maritime-based development. Through a comparative analysis of international practices and Iran's existing regulatory system, the study explores how standards can act as instruments for improving safety, sustainability, and economic growth. Ultimately, it aims to provide practical recommendations for aligning Iran's maritime framework with global technical and legal standards, thereby fostering a stronger, safer, and more sustainable maritime sector.

2. Conceptual Framework and Literature Review of Maritime Standards

1.2. Definition of Maritime Standards

Maritime standards are formalized criteria and specifications designed to ensure the safety, efficiency, and sustainability of maritime operations. These standards encompass technical, operational, safety, and environmental dimensions, guiding ship design, navigation, port operations, and pollution prevention. Technical standards specify the structural and mechanical requirements for vessels, including hull integrity, machinery, and onboard equipment, whereas operational standards define protocols for crew management, navigation, and emergency response [1].

Safety standards focus on reducing accidents and protecting life at sea, as codified in conventions such as SOLAS, while environmental standards, exemplified by MARPOL, aim to prevent marine pollution and promote sustainable shipping practices [2],[5].

2.2. Types of Maritime Standards

Maritime standards can be categorized into four main types:

1. Technical Standards: Cover vessel construction, materials, machinery, classification rules, and equipment certification [3], [6].
2. Safety Standards: Include navigation rules, life-saving appliances, firefighting systems, and emergency preparedness as defined in STCW and SOLAS [2], [10].
3. Environmental Standards: Regulate emissions, ballast water management, oil discharge, and waste handling to comply with MARPOL and ISO environmental standards [11].
4. Operational Standards: Address crew training, watchkeeping, port procedures, and ship management practices, ensuring that both personnel and organizational processes meet international benchmarks [1].

3.2. International Standardization Organizations

Several international organizations play a central role in developing and harmonizing maritime standards:

International Maritime Organization (IMO): A specialized UN agency responsible for creating conventions, codes, and guidelines to ensure maritime safety and environmental protection [2].

International Organization for Standardization (ISO): Develops technical standards applicable to shipbuilding, port operations, and maritime management systems [11].

International Association of Classification Societies (IACS): Provides unified technical requirements and classification rules adopted by major classification societies worldwide, bridging the gap between legal conventions and practical ship inspection [9].

These organizations collectively provide a structured framework that ensures global interoperability, safety, and environmental compliance in maritime operations.

4.2. Literature Review

The literature on maritime development highlights the central role of technical and legal standards in ensuring maritime safety, operational efficiency, and environmental protection. According to Chircop, Coffen-Smout, and McConnell [1], maritime law and governance have evolved through the codification of international conventions under the

International Maritime Organization (IMO), particularly the Safety of Life at Sea (SOLAS), Marine Pollution (MARPOL), and Standards of Training, Certification and Watch-keeping (STCW) conventions. These conventions establish the global framework for ship construction, pollution control, and crew training—forming the core of modern maritime regulation.

Classification societies, including the American Bureau of Shipping (ABS), Det Norske Veritas (DNV), Lloyd's Register, and ClassNK, have complemented these conventions by developing detailed technical standards for ship design, materials, machinery, and safety inspections [3], [15]. As Goulielmos argues, the work of classification societies bridges the gap between legal requirements and practical implementation, thereby promoting reliability and accountability within the maritime sector [8]. The International Association of Classification Societies (IACS) further enhances standardization by coordinating unified requirements among its members to ensure consistency and interoperability in global shipping [9].

Several studies emphasize that the adoption of international standards contributes directly to sustainable maritime development. Bateman notes that standardization improves not only ship safety and environmental protection but also trade competitiveness by ensuring compliance with global insurance and port state control systems [7].

In this sense, standards serve as both a technical instrument and a policy tool for achieving maritime-based economic growth. Countries such as Norway, Japan, and South Korea have successfully aligned their national frameworks with IMO and ISO standards, resulting in advanced maritime clusters and resilient marine economies [4] [14].

In contrast, research on Iran's maritime system suggests persistent gaps between national regulations and international norms [4]. Although Iran has ratified major IMO conventions, challenges remain in the areas of technical supervision, port state control, and the integration of updated standards into domestic law. The Iranian Ports and Maritime Organization [13] has made progress in establishing safety guidelines, yet the lack of an independent classification authority and limited training consistent with STCW requirements have hindered full compliance. As a result, Iran's maritime industry operates below its potential

capacity in contributing to blue economy development.

Overall, the literature underscores that maritime standards are not merely regulatory obligations but strategic drivers of sustainable development. Modernizing these standards and ensuring their effective implementation can significantly enhance national competitiveness, safety, and environmental stewardship within the maritime domain.

3. Comparative Analysis of Maritime Standards in Selected Countries

1.3. Overview

A comparative examination of maritime standards across advanced maritime nations reveals significant differences in regulatory frameworks, institutional structures, and approaches to safety and sustainability. Countries such as Singapore, Norway, and Japan have developed comprehensive systems that integrate international norms with domestic innovation. This chapter explores how these countries have institutionalized maritime standards and what lessons can be drawn for Iran's maritime industry.

2.3. Singapore: A Model of Integrated Maritime Governance

Singapore is widely regarded as a global leader in maritime management. Its success stems from the Maritime and Port Authority of Singapore (MPA), which harmonizes international standards set by the International Maritime Organization (IMO) with local regulations. The MPA enforces high-level technical and safety standards, regularly updating them in line with IMO conventions such as SOLAS, MARPOL, and STCW.

Moreover, Singapore's emphasis on digitalization and sustainability, for example, through the Smart Port and Green Port initiatives shows how standards can promote innovation. The coordinated application of technical, environmental, and operational benchmarks has turned Singapore into a maritime hub that balances economic efficiency with environmental protection.

3.3. Norway: Leadership in Safety and Environmental Standards

Norway's maritime governance is deeply rooted in its commitment to safety culture and environmental stewardship. The Norwegian Maritime Authority

(NMA) plays a central role in implementing national standards aligned with IMO and European Maritime Safety Agency (EMSA) directives. Norway was among the first to adopt advanced ballast water management systems and low-emission vessel technologies.

The country's investment in research, especially through the SINTEF Ocean Research Institute, has led to continuous updates of safety codes and ship design standards. Norwegian maritime education institutions also play a key role in standard dissemination by training professionals in compliance with both national and international frameworks.

4.3. Japan: Tradition and Technology Combined

Japan represents a unique blend of maritime tradition and high technology. The Japanese Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) oversees a robust framework of safety and environmental standards. Japan's shipbuilding industry adheres closely to International Association of Classification Societies (IACS) regulations while also developing domestic innovations to improve ship efficiency and safety [9].

Japan's Maritime Bureau has also been instrumental in advancing research on autonomous ships and decarbonization technologies. This dual focus on technological modernization and strict compliance has strengthened Japan's maritime competitiveness on the global stage.

5.3. Lessons for Iran

A comparison with these leading maritime nations suggests several key insights for Iran:

1. **Institutional Integration:** A unified authority—similar to Singapore's MPA—could help streamline Iran's maritime governance system.
2. **Safety and Research Orientation:** Following Norway's model, Iran should enhance investment in maritime safety research and education.
3. **Technology and Innovation:** Inspired by Japan, Iran could adopt new technologies such as smart navigation and green shipping solutions.
4. **Alignment with IMO Conventions:** Regular harmonization of domestic regulations with IMO standards would improve international cooperation and trade credibility.

By learning from these experiences, Iran can build a more resilient and internationally compliant maritime system that supports marine-based economic growth.

4. The Current Status of Maritime Standards in Iran

1.4. Institutional and Legal Framework

Iran's maritime sector is governed primarily by the Ports and Maritime Organization (PMO), under the supervision of the Ministry of Roads and Urban Development. The PMO is responsible for regulating ship safety, port operations, and maritime inspections in accordance with both national law and international conventions ratified by Iran [4]. Iran has officially ratified key IMO conventions, including SOLAS, MARPOL, and STCW, which provide the foundational framework for ship safety, environmental protection, and crew training [5].

Despite this formal compliance, several studies indicate that Iran's maritime standards face challenges in practical implementation. These challenges include gaps in inspection mechanisms, outdated technical regulations, and insufficient alignment with the latest IMO updates [14].

For instance, the enforcement of technical classifications for ship hulls and machinery remains inconsistent across ports, limiting the overall safety and operational reliability of the fleet.

2.4. Technical and Safety Standards

Iran has developed domestic guidelines for ship construction, classification, and safety procedures, primarily outlined in the Guide to Implementation of Maritime Safety and Technical Regulations [4]. However, compared to international best practices, these guidelines often lag behind in terms of technological updates and standard harmonization. Safety standards such as life-saving equipment, firefighting systems, and navigational aids are generally compliant but suffer from limited inspection frequency and inconsistent documentation.

Moreover, training of maritime personnel, though mandated by STCW standards, shows gaps in practical implementation. Many seafarers report insufficient hands-on training for emergency procedures and operational compliance, which can affect overall safety levels on board [4].

3.4. Environmental Standards

Environmental regulation in Iran aligns formally with MARPOL conventions, including oil spill prevention, ballast water management, and emission control [5]. However, the monitoring and enforcement of these standards are uneven, particularly in southern ports along the Persian Gulf. While national legislation exists, inadequate technical equipment for environmental surveillance and limited reporting mechanisms reduce the effectiveness of these environmental protections [14].

3.4. Challenges and Gaps

Based on current research, the main challenges for Iran's maritime standards include:

1. Outdated Technical Regulations: Delays in updating domestic codes in line with IMO revisions.
2. Weak Inspection and Enforcement: Inconsistent application of classification rules and safety inspections.
3. Insufficient Integration with International Standards: Limited harmonization with ISO and IACS standards.
4. Training Gaps: Crew and personnel training not fully aligned with modern STCW requirements.
5. Coordination Deficiencies: Lack of centralized oversight between PMO, Navy, and port authorities.

Addressing these gaps is essential to enhance maritime safety, international compliance, and the potential for marine-based economic growth.

5. The Role of Maritime Standards in Marine-Based Development

1.5. Standards as Drivers of Marine-Based Development

Maritime standards play a critical role in promoting marine-based economic growth by ensuring safety, operational efficiency, and environmental sustainability. The adoption of international standards—covering ship construction, navigation, pollution control, and crew competency—provides a foundation for developing a competitive and resilient maritime sector [7]; Chircop, Coffen-Smout, & McConnell, 2020) [1]. By aligning domestic regulations with IMO conventions, ISO guidelines, and IACS classification rules, countries

can enhance trade credibility, attract foreign investment, and support the expansion of port and shipping infrastructure.

2.5. Economic Impacts of Standardization

Standardized maritime practices directly contribute to economic development by:

1. Reducing Operational Risks: Minimizing accidents and technical failures lowers costs for shipping companies and insurers [3].
2. Facilitating International Trade: Compliance with international standards enables easier port access and strengthens participation in global supply chains [14].
3. Encouraging Innovation: Standardization encourages adoption of green technologies, digital navigation systems, and efficient vessel designs, which in turn boost productivity and competitiveness [12].

In Iran, insufficient standardization has historically limited the growth of marine-based industries, reducing the country's potential to fully exploit its strategic maritime position in the Persian Gulf, the Gulf of Oman, and the Caspian Sea [4]. Improving standards could significantly enhance ship safety, port efficiency, and the overall maritime value chain, thereby supporting a sustainable blue economy.

3.5. Environmental and Sustainability Benefits

Maritime standards also provide a framework for environmental protection, a key factor for sustainable marine-based development. Adoption of MARPOL and ISO environmental standards ensures reduced oil spills, emissions, and ballast water contamination [5], [11]. Countries with strong environmental compliance, such as Norway and Japan, demonstrate that harmonized standards can simultaneously protect marine ecosystems and support long-term economic growth.

4.5. Policy Recommendations for Iran

Based on international experiences and current gaps in Iran's maritime system, the following strategies are recommended:

2. Update Technical Regulations: Ensure that shipbuilding, machinery, and classification rules are consistent with the latest IMO and IACS standards.
2. Strengthen Inspection Mechanisms: Improve port state control, vessel classification, and compliance audits to enhance safety and reliability.

3. Enhance Training Programs: Align seafarer education with STCW standards and practical operational training.

4. Promote Innovation and Green Shipping: Encourage adoption of digital navigation, emission reduction technologies, and energy-efficient vessel designs.

5. Institutional Coordination: Establish a centralized maritime authority to coordinate enforcement, regulation, and education across agencies.

By implementing these measures, Iran can leverage standards as a key driver of marine-based economic development, fostering international competitiveness and sustainable growth.

6. Comparative Analysis and Lessons for Iran

1.6. Comparative Overview

A comparative analysis of maritime standards in leading maritime nations—such as Singapore, Norway, and Japan—highlights key factors that contribute to a safe, efficient, and sustainable maritime sector. Singapore integrates international conventions with national regulations through the Maritime and Port Authority (MPA), ensuring seamless compliance with SOLAS, MARPOL, and STCW standards while promoting technological innovation [14]. Norway emphasizes a strong safety culture and environmental stewardship, enforced by the Norwegian Maritime Authority (NMA), and invests heavily in maritime research and education [8]. Japan combines advanced shipbuilding technology with rigorous regulatory compliance, aligning domestic standards with IACS classification rules while promoting innovation in digital navigation and green shipping [12].

2.6. Lessons Learned

From these examples, several critical lessons emerge for Iran:

1. Centralized Governance: Establishing a unified maritime authority, similar to Singapore's MPA, can streamline regulatory enforcement and coordination.

2. Safety and Environmental Culture: Adopting Norway's emphasis on safety culture and environmental monitoring will enhance operational reliability and sustainability.

3. Technological Modernization: Following Japan's approach, Iran can integrate digital navigation, energy-efficient vessels, and emission reduction technologies to boost competitiveness.

4. Education and Training: Aligning maritime education programs with STCW requirements ensures highly skilled seafarers and effective operational compliance.

5. International Alignment: Continuous harmonization of national regulations with IMO, ISO, and IACS standards strengthens trade credibility and fosters global cooperation.

3.6. Implications for Iran's Maritime Development

The comparative analysis indicates that Iran's current maritime framework can benefit significantly from adopting international best practices. Specifically:

Updating technical and safety regulations to match global standards will reduce operational risks and improve fleet reliability.

Strengthening inspection, classification, and port state control mechanisms will enhance compliance and safety.

Encouraging innovation and adoption of green technologies will support a sustainable blue economy.

Effective institutional coordination across PMO, naval authorities, and educational institutions will ensure consistency and regulatory efficiency.

By applying these lessons, Iran can transform its maritime industry into a globally competitive, sustainable, and safe sector capable of supporting marine-based economic growth.

7. Conclusions and Policy Recommendations

1.7. Conclusions

This study highlights the pivotal role of maritime standards in promoting safe, efficient, and sustainable marine-based development. The analysis demonstrates that standards covering technical, operational, safety, and environmental aspects—are not merely regulatory obligations

but strategic instruments for economic growth. Iran's maritime sector, while formally aligned with major IMO conventions such as SOLAS, MARPOL, and STCW, faces challenges in practical implementation, including gaps in inspection, training, technical regulations, and environmental monitoring [4]; [14].

Comparative lessons from leading maritime nations—Singapore, Norway, and Japan—underscore the benefits of centralized governance, rigorous safety culture, technological innovation, and international alignment. These experiences suggest that Iran can significantly enhance its maritime sector by modernizing standards, strengthening enforcement, and promoting training and innovation.

2.7. Policy Recommendations

Based on the analysis, the following policy recommendations are proposed for Iran:

1. **Update and Harmonize Regulations:** Regularly revise domestic technical, safety, and environmental standards to align with the latest IMO, ISO, and IACS requirements.
2. **Strengthen Inspection and Enforcement:** Enhance port state control, ship classification, and safety audits to ensure compliance and operational reliability.
3. **Enhance Training Programs:** Align maritime education and professional training with STCW standards, emphasizing practical skills and emergency preparedness.
4. **Promote Technological Innovation:** Encourage adoption of digital navigation systems, energy-efficient vessels, emission reduction technologies, and green shipping solutions.
5. **Institutional Coordination:** Establish a centralized maritime authority to improve coordination among PMO, naval, port, and educational institutions.
6. **Support Research and Development:** Invest in maritime research centers and partnerships with international institutions to develop domestic expertise in shipbuilding, port management, and environmental protection.

Implementing these recommendations can transform Iran's maritime sector into a globally competitive, safe, and sustainable system, capable of supporting a thriving marine-based economy and enhancing international trade.

Maritime standards serve as a strategic link between regulatory compliance, safety, environmental protection, and economic development. For Iran, updating standards, strengthening enforcement mechanisms, and fostering innovation are critical steps toward achieving sustainable marine-based growth. By learning from international best practices and integrating them with domestic capabilities, Iran can maximize the economic potential of its strategic waterways and ports while ensuring long-term environmental and operational sustainability.

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