Research and Development Agenda for the Philippine Maritime Sector: Results from Stakeholder Consultations

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Abstract. The objective of the study is to identify the most critical Science and Technology (S&T) interventions or solutions that need to be developed and prioritized to advance and transform maritime transport in the Philippines. We present the results of our consultations with 42 stakeholders, representing a total of 16 organizations from the government agencies, academe, private sector and maritime associations. We group the responses of our stakeholders into topics and identify three R&D themes: development of fleet and facilities, digital transformation of the maritime sector, and maritime security/safety and environmental protection. Our stakeholders rank the protection of marine environment as the most important, while the development of autonomous ships as the least important. We recommend that the results of our study be used by relevant agencies and institutions as basis for the identification and prioritization of maritime-related transport projects.

Keywords: Maritime transport, Priorities, Policies, Stakeholder consultation

1. INTRODUCTION

In *Pagtanaw 2050*, a foresight document published by the Department of Science and Technology which charts the strategic path for the Philippines in the areas of science, technology and innovation (STI), the central vision underscored is that of the Philippines as a "United and Inclusive, Prosperous, and Sustainable Archipelagic, Maritime Nation" (NAST, 2021).

Considering the archipelagic profile of the Philippines, the development of the maritime transport sector is envisioned to contribute significantly to the attainment of this shared vision. In fact, at the core of the foresight document are 12 key operational areas, which include transportation. The document states that, to achieve the vision, there is a need to pursue improvements in transportation such as "ports, roll-on-roll-off facilities, expressway and road networks, and public transport, coupled with a strategic combination of various water, land, and air transportation modes" (NAST, 2021).

Nonetheless, despite the widespread recognition of the enabling role of maritime transport, the advancement of the maritime industry has been limited (see, for example, MARINA, 2018). The reasons are vast and complex, but we think this may be partly due to the limited innovation and deployment of science and technology (S&T)

solutions/interventions in the sector. The absence of a clear STI R&D agenda for maritime transformation partly accounts for the limited STI investments in the sector.

The purpose of this article is to present the areas of S&T intervention in maritime transport for further research and development. Although not a full-blown roadmap, our paper is useful in assisting decision-makers in the academe, government and private sector align their efforts towards a common research and development (R&D) agenda.

2. REVIEW OF RELATED STUDIES

2.1. National Development Plans and Roadmaps for the Maritime Sector

By now, the Philippines has produced a few development plans and roadmaps for the maritime sector, such as the Maritime Industry Development Plan (MIDP) (2019-2028) of the Maritime Industry Authority (MARINA, 2018), Philippine Coast Guard Maritime Strategy (PCG, 2021), the Green, Resilient and Smart Port Strategy (GRaSPS) of the Philippine Ports Authority (PPA, 2018). What these documents present are the long-term sectoral strategies for the enhancement of security, ports and maritime industry in the Philippines. What is missing in all these existing documents is an S&T Innovation Roadmap for the transformation of the Philippine maritime sector. Recently, the Department of Science and Technology also published *Pagtanaw 2050*, the agency's Integrated STI roadmap, which among other things covers maritime transportation (NAST, 2021). The document highlights five technologies that may transform the sector: digital technology, nanotechnology, biotechnology, neurotechnology and clean technology (NAST, 2021). However, *Pagtanaw 2050* is not a roadmap but a foresight document. In Southeast Asia, one of the countries that has already formulated its own maritime innovation roadmap is Singapore: see, for example, the Singapore Maritime R&D Roadmap 2030 (SMI and MPA, 2019).

2.2. Maritime Innovation Studies

The transformation of the maritime sector is typically premised on the sector's digital transformation (e.g., Tijan et al, 2021). Sanchez-Gonzales et al (2019), for instance, enumerate eight digital domains for the digitalization of maritime transport: autonomous vehicles and robotics; artificial intelligence; big data; virtual reality, augmented and mixed reality; internet of things; the cloud and edge computing; digital security; and 3D printing and additive engineering. On the other hand, de la Peña Zarzuelo et al (2020) highlight the following: Internet of Things and sensing solutions; cybersecurity; horizontal and vertical system integration; cloud computing; 3D printing and additive manufacturing; big data and business analytics; augmented reality; and simulation and modeling. However, in an archipelagic country like the Philippines, other dimensions of the transformation, besides digitalization, must be considered. So far, no study has been conducted yet which gathered a wide range of stakeholder responses on the potential S&T interventions for the transformation of the Philippine maritime sector.

3. METHODS

The question we sought to answer is: *"What are the most critical S&T interventions or solutions that need to be developed and prioritized to advance and transform maritime transport in the Philippines?"* Setting of research agenda drawn from a broad consultation of stakeholders is an established practice in the literature. The process of stakeholder engagement involves three major steps: (1) stakeholder mapping (to ensure that all relevant stakeholders

from a wide range of sectors are identified and invited), (2) consultation proper, and (3) consolidation/building of consensus around the identified research agenda (e.g., de Veyra et al, 2019).

In identifying the possible list of research topics, some studies employ a top-down approach of agenda-setting: first by conducting a thorough literature review to identify major research themes, then proposing core domains of agenda setting and finally building a consensus around these domains using modified Delphi technique with the stakeholders (Gobat et al, 2015). Other studies take a bottom-up approach, by collecting data from the ground, such as, for example, social media (Martin and Grüb, 2016). A few studies combine the bottom-up approach with a complementary top-down comparison with the literature to set the research agenda (Gudowsky et al, 2017).

In this paper, we adapted the method used by Beck et al (2022) in identifying and prioritizing active transport research agenda. We chose this method since it is a bottom-up approach (maritime transport research in the Philippines, unlike in other countries, is still relatively nascent; thus, the literature is not yet mature, and using a top-down approach only generates very few ideas), and it has been applied in the agenda-setting within the transport or mobility domain. The method of Beck et al (2022) consists of three phases:

- Phase 1: Generation of STI initiatives
- Phase 2: Thematic analysis and topic consolidation/clustering of STI initiatives
- Phase 3: Prioritization of STI initiatives

Each of the phases is explained below.

3.1. Phase 1: Generation of STI Initiatives

3.1.1. Reference group

A reference group was established which includes experts and key members in maritime transport representing the academe, government, private organizations and associations (Table 1). We invited as many stakeholders as possible. We relied on the directories by maritime government agencies as well our personal contact list in identifying and inviting relevant maritime stakeholders to participate as members of the reference group. In the end, we were able to invite stakeholders from 16 organizations.

Table 1. Reference group of maritime transport sector stakeholders

Sector	Organization / Institution (16)	Number of stakeholders consulted (42)
Government (5)	Maritime Industry Authority (MARINA)	8
	Philippine Ports Authority (PPA)	6
	Philippine Coast Guard (PCG)	1
	National Maritime Polytechnic (NMP)	2
	Department of Transportation	3
Academe (5)	University of the Philippines	3
	University of Cebu	1
	Cebu Technological University	1
	Mariners' Polytechnic Colleges, Canaman	5
	Asian Institute of Maritime Studies	5
Private sector (4)	F.F. Cruz Shipping Corporation	2
	Chesteel Marine Industrial Corporation	1

	Trigon Shipyard Corporation Philippine Span Asia Carrier Corporation (PSACC)	1 1
Association (2)	Marine and Technical Superintendent Association of the Philippines Inc. (MTSAP) Association of International Shipping Lines (AISL)	1 1

3.1.2. Interview-based consultation

As soon as we secured the agreement of the invited stakeholders to participate in the study, we scheduled face-to-face or virtual consultations with them. We conducted semi-formal interviews, lasting at least one hour. We followed two methods in conducting the interviews (Figure 1). Method 1 begins with identifying the needs, challenges and paint points of the maritime sector from the perspective of the stakeholder, then proceeds by enumerating the corresponding priority objectives and programs and ends with a list of S&T solutions/interventions. Method 2 starts by surveying the global landscape of S&T solutions/interventions then listing down those that are applicable in the local/national context. The STI initiatives identified via both methods are then combined.

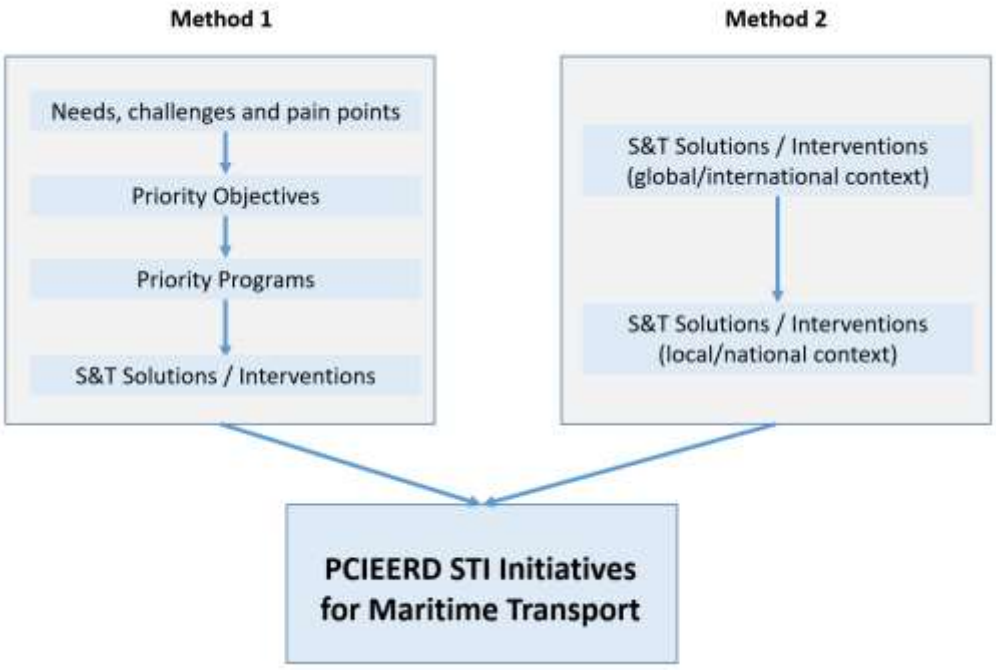

Figure 1. Methods of consultation

3.2. Phase 2: Thematic analysis and consolidation/clustering of STI initiatives

A thematic analysis of STI initiatives identified in the Phase 1 interview-based consultation was conducted to identify common themes (Figure 2). We follow an open coding of first-order STI initiatives, then abstract them into second-order clusters of topics, and finally, group into themes. These three orders of data analysis are then organized into the so-called "data structure". The entire method is an iterative process: emergent findings/concepts are always checked back and forth with the literature/theories as well as the data collected.

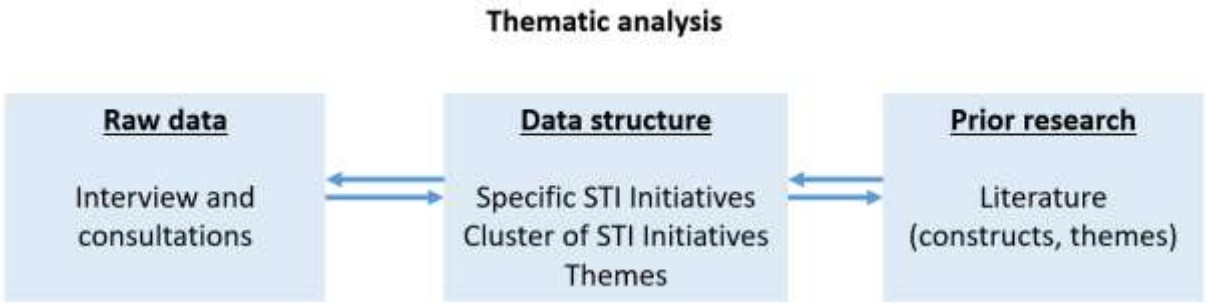

Figure 2. Method of thematic analysis; the double arrow indicates the iterative nature of the exercise.

3.3. Phase 3: Prioritization of STI initiatives

Participants were asked to rate the consolidated STI initiatives in terms of their importance in advancing maritime transport in the Philippines using a 5-point Likert Scale ("not at all important", "slightly important", "moderately important", "very important" and "extremely important"). In contrast to prior literature that has used multiple criteria to prioritize research questions, we determined not to apply multiple criteria and simply ask participants to provide a single rating in terms of the initiative's importance in advancing maritime transport in the Philippines (see also Beck et al, 2022).

4. RESULTS AND DISCUSSION

4.1. Focal R&D Themes

Based on the consultations, we identify three focal R&D themes for the maritime sector (Tables 2, 3, and 4):

- Development of fleet and facilities
- Digital transformation of the maritime sector
- Maritime security, safety and environmental protection

4.1.1. Development of fleet and facilities

Table 2. Development of fleet and facilities

THEME 1: Development of fleet and facilities		
Cluster of topic	**Program**	**STI Initiatives/Projects**
(1) Modern, hybrid-functional and low-carbon vessels	Autonomy	Design and development of Marine Autonomous Surface Ship (MASS)
	Vessel for specific water typology and functions	Design and development of new vessels for various water typologies (e.g., Laguna Lake) Prototype development of vessels/water taxi for bay, river and coastal waters Prototype of tourist bancas Development of a prototype hull for municipal fishing Hybrid (sea-air/land) and disaster-resilient vessels
	Electrification / Renewable / Alternative Fuel	Development of modern vessels utilizing renewable and alternative energy sources Electrification of marine vessels

	Retirement of old vessels	Recycling index for boats and vessels
	Design and standards	Development of standards for vessels
(2) Testing facility	Towing Tank	Establishment of a towing tank facility for ship design and testing

The Philippines is a maritime country, consisting of 7,100 islands and a coastline of 36,000km. Globally, it ranks 7th in terms of the number of islands and 5th by the length of the coastline. Its bays, coastal and oceanic waters cover an area that is seven times larger than the country's total land area. Against this background, water transport plays a vital role in the daily economic affairs of the country. However, most vessels are obsolete and old, carbon-intensive, and second-hand. As shown in Table 2, key to the modernization and competitiveness of the maritime industry is a robust R&D on the development of modern and hybrid-functional vessels, including the standardization of design and specifications. Furthermore, with the government's push to retire or replace old and unsafe vessels, there is a need to establish ship-scrapping and ship-recycling facilities. All of these can also support Program 1 of the Maritime Industry Development Plan, namely, "Upgrading of Domestic Shipping in Support of the Philippine Nautical Highway Development".

Moreover, decarbonization of shipping and maritime transport is an imperative that requires the electrification of the industry, and the widespread use of cleaner fuels and renewable energy sources.

Finally, to support the development of ship design and testing prior to actual construction, advanced towing tank facilities capable of simulating motion and performance of model ships subject to various wind and wave conditions are needed.

4.1.2. Digital transformation of the maritime sector

Table 3. Digital transformation of the maritime sector

THEME 2: Digital Transformation of the maritime sector		
Cluster of topic	**Program**	**R&D Initiatives/Projects**
(1) Smart ports and terminals	Efficient port operations and services	Just-in-Time (JIT) Port System Maritime National Single Window[1] Port Community Systems (PCS) Ro-Ro scheduling, booking and payment system Terminal operating system (TOS) Automated and integrated passenger and cargo ticketing and manifest system
	Port Planning	Port Digital Twins Demand analysis and forecasting Port capacity analysis
	Digitization and Data	Digitized registry and port database
	Cargo logistics	Cargo monitoring and handling systems

[1] The single window system may enable "all stakeholders involved in the business process to input the data and information used by other stakeholders only once". Implementation of a National Single Window as a single-entry point has "the potential to harmonize and standardize the information exchange between commercial and administrative stakeholders and to provide fast, reliable, paperless, and efficient transactions" (Tijan et al, 2019).

		Remote monitoring and non-invasive inspection of the container and cargo content/load, especially if they are carrying hazardous or dangerous materials
(2) Sea space and maritime traffic management	Surveillance/ monitoring systems	Automatic movement reporting and monitoring in port waters Deployment of drones for surveillance and mapping
	Proactive traffic management	Intelligent passage analysis and routing for local navigation
(3) Data and digital platforms	Digitization and data harmonization, integration, sharing and access	Unified data standards and protocols Maritime data hub
	Maritime digital platform development	Maritime cloud One-stop integrated digital platforms / Integration of stand-alone applications (e.g. integration of e-libraries of individual agencies) Establishment of centralized maritime data bank and knowledge center
	Passenger information	Intermodal trip or schedule information system for seamless passenger travel
(4) Human element and training	Simulators and Virtual/Augmented Reality for Training / Education	Intensive use of simulation-based training and education
	Online platforms	Development of online course platform and learning management system for superintendents, seafarers, cadets and other workers

Another vital aspect to the modernization of the maritime sector is its transformation through digital technologies (Table 3). These technologies have the potential to bring about profound organizational changes which lead to the disruption and redefinition of existing business processes. Four R&D clusters have been identified from the stakeholders' consultations: smart ports and terminals, sea space and maritime traffic management, data and digital platforms, and human element and training.

The concept of "smart ports and terminals" refers to the use of advanced technologies to improve operational efficiencies and business reliability of ports and terminals. This is fully aligned with the Philippine Ports Authority's "Green Resilient and Smart Port Strategy" (GRaSPS). According to ABD (2020), the process of evolution towards smart ports/terminals involves five stages: data capture (digitization and sensors), collaboration (visualization, analysis and integration), decision support (optimization), learning (simulation and digital twin) and automation. Several of the R&D initiative/projects listed in Table 3 under "Smart ports/terminals" are aligned with one of these phases.

The term "Sea space and maritime traffic management" is borrowed from Singapore Maritime Transformation R&D Roadmap 2030. With about 100,000 ship calls for the first quarter of 2022 alone (and this is bound to increase even more with increasing trade and transshipment), there is a need for an effective management of movements of vessels in Philippines through monitoring and routing.

According to Pettey (2019), data and analytics are the "key accelerant" of the digitization and digitalization of any organization. "Data and digital platforms" are thus included to acknowledge the critical role that both play in the digital transformation of the maritime sector. To fully leverage the benefits of digitalization, data must be harmonized and made accessible/shareable; various players be integrated or onboarded on common platforms; and applications (such as passenger information system) be developed.

"Human element and training" means the digitalization of maritime education and training by means of developing simulation tools and courses. Considering the Philippines' position as a source of manpower (seafarers, cadets, superintendents, etc.), it is crucial for the maritime manpower industry (such as universities and schools) to be able to provide world-class training and education, even amidst the pandemic.

4.1.3. Maritime safety, security and environmental protection

Table 4. Maritime security/safety and marine environmental protection

Theme 3: Maritime Safety and Security / Environmental Protection		
Cluster of topic	**Program**	**R&D Initiatives/Projects**
(1) Maritime Safety and security	Appliances development	Life-saving appliances for passengers and fishing boats
	Safety standards	Development of standards for assessing wave-impact stability hazard
	Tracking and Rescue	Development of Automatic Identification System (AIS) for bancas and other small vessels
	Asset monitoring and diagnostics	Real-time lighthouse monitoring system
(2) Environment protection	Waste, invasive species, and marine environment	Localized vessel tracking system for Marine Protected Areas (MPAs)
		Baseline inventory study of invasive species
		Shore waste reception facility

The final R&D theme concerns maritime safety and security, and marine environmental protection (Table 4). This theme addresses issues of maritime accidents, security threats and environmental hazards (e.g., waste, fouling).

Based on available data, there are about 483 maritime accidents investigated by MARINA in 2016-2020 (MARINA, 2020). Of these, 81 are considered "very serious accidents", which, based on the IMO definition, involve "total loss of the ship, loss of life or severe pollution" (Batalden and Sydnes, 2014). Furthermore, the Philippines has seen some of the worst sea disasters during peacetime.

The term "maritime security" was officially defined in the National Marine Policy issued on 8 November 1994 as "a state in which the country's marine assets, maritime practices, territorial integrity, and coastal peace and order are protected, conserved, preserved and enhanced" (quoted in Palma, 2012). Maritime security threats include piracy, kidnapping, armed robbery, terrorism, disputes, and illegal fishing.

Aside from safety and security issues, there is a need to ensure the protection of the marine environment from pollution, waste, fouling and invasive species. It is in this context that the country is pursuing a maritime strategy, centered on the enhancement of maritime

safety and protection of the environment, in compliance to the commitments of the country to the International Maritime Organization (IMO) (MARINA, 2021).

Issues concerning maritime safety, security and environmental protection are too broad, which cannot be addressed by S&T alone. Specifically for the part of marine plastic litter pollution, the lack of baseline data to define the extent of the problem is concerning; here S&T interventions (*i.e.*, basic research) are needed for science-based policymaking (Abreo, 2018; Paler, 2020; Omeyer, et al., 2022; Paler, et al., 2022). However, given that some of these issues can be tackled by S&T, Table 4 lists possible programs and S&T interventions/initiatives for research and development related to this theme as identified by the stakeholders.

4.2. Prioritization

Given the number of STI interventions gathered from the consultations, we also attempt to evaluate their level of importance. Table 5 shows the mean and standard deviation of the ratings of our stakeholders from 16 organizations. Each organization is asked to rate each topic cluster by the level of importance and prioritization (with 5 as the highest rating). Since only one rating per topic is received from each organization, the total number of ratings per topic is only 16.

Table 5. Colors reflect the following themes: Development of fleet and facilities; Digital transformation of the maritime sector; Maritime safety, security and environmental protection

R&D Theme	Mean	SD
Marine environment protection	4.81	0.39
Safety standards	4.69	0.58
Development of standards for vessels	4.67	0.60
Efficient port operations and services	4.63	0.60
Digitization and Data	4.56	0.61
Tracking and Rescue	4.56	0.70
Online platforms	4.53	0.72
Proactive traffic management	4.50	0.61
Use of electrification / Renewable / Alternative Fuel	4.44	0.70
Maritime digital platform development	4.40	0.71
Digitization and data harmonization, integration, sharing and access	4.38	0.86
Vessel for specific water typology and functions	4.33	0.87
Port Planning	4.31	0.77
Surveillance/ monitoring systems	4.25	0.83
Appliances development	4.13	0.72
Asset monitoring and diagnostics	4.13	0.72
Passenger information	4.13	0.78
Simulators and Virtual/Augmented Reality for Training / Education	4.13	1.11
Cargo logistics	4.06	0.90
Retirement of old vessels	3.88	0.99
Establishment of towing tank facility	3.80	1.17
Autonomous ships	3.29	0.88

From the table, we see that **marine environmental protection** (mean of 4.81) is considered by our stakeholders to be the most important topic for research and development. This includes protection of marine environment from waste disposal and pollution from ships, terminals and ports, and other facilities. Development of **safety standards** (mean of 4.69) – i.e., setting the standards for evaluating the safety of vessels – ranks second. **Development of standards for vessels** (mean of 4.67) ranks third. For this, the MARINA has to partner with the Department of Trade and Industry (DTI) to develop the Philippine National Standards (PNS) for ship building and vessel development. **Efficient port operations and services** (mean of 4.63) comes next. This is part of a bigger program of the sector's digital transformation, i.e., the use of digital technologies, capabilities and platforms to improve the efficiency of operations and services. **Digitization and Data** and **Tracking and Rescue** rank in the top 5 (mean of 4.56).

While the topic of **autonomous ships** is becoming prominent in the literature (Munim, 2019), our respondents think that in the context of the Philippines, they are still emerging and uncertain, and thus, should be at this point be given the least importance.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

We present in this paper the results of our consultations with stakeholders from the government agencies, academe, private sector and maritime associations on the research and development agenda for the Philippine maritime sector. We find three R&D themes: development of fleet and facilities, digital transformation of the maritime sector, and maritime security/safety and environmental protection. Our stakeholders rank the protection of marine environment as the most important, while the development of autonomous ships as the least important.

To move forward the maritime research agenda, we first recommend that the results of our study be used by relevant agencies and institutions as the basis for the identification, prioritization and, more importantly, funding allocation of maritime-related transport projects. Second, we recommend that government agencies such as MARINA and the Department of Trade and Industry (DTI), in close consultation and collaboration with the industry, take the lead in the standardization (i.e., development of Philippine National Standards for safety, vessels and data), since standards can only be specified and set by regulatory government agencies. Third, in order to pursue digitalization and development of automated tracking systems for rescue operations, we recommend that a collaboration between the academe and private IT firms with expertise on digital transformation and automation, e.g., cloud service providers (Amazon Web Service, Google Cloud Platform and Azure), be pursued.

DISCLAIMER

The views in this article do not reflect the position of the institutions that the authors represent. Any errors or misinterpretations are entirely the fault of the authors.

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