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EARTH OBSERVATORY DATA FOR MARITIME SILK ROAD DEVELOPMENT IN SOUTH EAST ASIA

Mohamad Shawkat Hossain[a], Mazlan Hashim[a,b]*

[a]Geoscience & Digital Earth Centre (INSTeG), Research Institute for Sustainable Environment, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
[b]Faculty of Geoinformation & Real Estate, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

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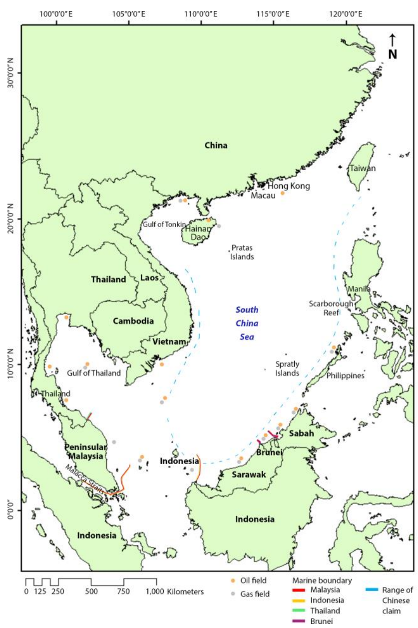
*Corresponding author
mazlanhashim@utm.my

Graphical abstract



Abstract

Malaysia is one of the leading maritime countries surrounded by the South China Sea. Since the emergence of Maritime Silk Road (MSR) concept and its operational implementation, economic growth, development and cooperation, particularly in the context of Southeast Asia (SEA) including Malaysia has enhanced, but simultaneously traffic congestion and tensions in the South China Sea through claiming Exclusive Economic Zone (EEZ) by the law enforcing agencies of the regional countries have increased. To trade China within SEA, has to follow longer shipping route, linking the mainland of China with ports throughout the Middle East, traversing the South China Sea. Given there are many uncharted and emerging islands in the South China Sea, that still undetected and therefore, delineation of these island boundaries could be a major step forward in reducing maritime tensions. An integrated MSR network plan can be developed through recognizing those islands as potential EEZ for the related regional countries based on international water boundary law suits. The set of initiatives recommended in this paper gives strategic focus to – how earth observatory (EO) data can be used in (1) delineating emerging islands, (2) designing and developing coastal infrastructural facilities, and (3) protecting the integrity of the maritime environment. The future study can emphasize on investigating the potential usefulness of EO data, inter alia optical and radar for mapping emerging islands, possibilities of appearing islands in future based on shallowness predicted from bathymetric and sedimentation data analysis, and forecast opportunities and risks of using those as MSR transportations. The environmental risks associated with water pollution, degradation of coastal habitats, and marine ecosystem health and vulnerabilities can be assessed by analysing current and historical EO data. The particular emphasis should be given on protecting environmental pollution in the effort to introduce the philosophy of sustainable development in the local maritime sector.

Keywords: Earth observatory data, Maritime Silk Road, South East Asia, emerging island, EEZ, maritime pollutions

Abstrak.

Malaysia adalah salah satu daripada negara-negara maritim terkemuka dikelilingi oleh Laut China Selatan. Sejak kemunculan konsep Jalan Sutera Maritim (MSR) dan pelaksanaan operasinya, pertumbuhan ekonomi, pembangunan dan kerjasama, terutamanya dalam konteks Asia Tenggara (SEA) termasuk Malaysia telah dipertingkatkan, tetapi pada masa yang sama berlaku kesesakan tarfik dan ketegangan di Laut China Selatan melalui tuntutan Zon Ekonomi Eksklusif (EEZ) dengan undang-undang agensi penguatkuasa negara-negara serantau telah meningkat. Untuk berdagang dalam SEA, China harus mengikuti laluan yang menghubungkan tanah besar China dengan pelabuhan-pelabuhan di seluruh Timur Tengah, menyeberangi Laut China Selatan. Memandangkan terdapat banyak kemunculan baru pulau-pulau kecil di Laut China Selatan yang masih belum tidak diterokai dan dipetakan, persempadanan pulau-pulau ini boleh menjadi satu langkah ke hadapan dalam mengurangkan ketegangan maritim. Pelan rangkaian MSR bersepadu boleh dikembangkan melalui mengiktiraf pulau-pulau dengan potensi EEZ bagi negara-negara serantau berdasarkan undang-undang sempadan laut antarabangsa. Set inisiatif yang dicadangkan dalam artikel ini memberi tumpuan strategik kepada - bagaimana data-data cerapan bumi (EO) boleh digunakan dalam: (1) menentukan sempadan kemunculan pulai-pulau kecil baru, (2) merekabentuk dan membangunkan kemudahan infrastruktur pantai, dan (3) melindungi integriti persekitaran maritim. Kajian masa depan boleh menekankan kepada kajian kegunaan potensi data EO, melibatkan data-data optik dan radar untuk kemunculan pulau-pulau baru, kemungkinan terdapat pulau-pulau diimasa depan boleh berdasarkan ramalan dari analisis kedalaman dan pemendapan, dan ramalan peluang dan risiko dalam laluan MSR. Risiko alam sekitar yang berkaitan dengan pencemaran air, kemusnahan habitat pantai, dan kesihatan ekosistem marin dan kelemahan boleh dinilai dengan menganalisis data-data EO semasa dan lama. Penekanan perlu diberikan untuk melindungi pencemaran alam sekitar dalam usaha mempelorori falsafah pembangunan mampan bagi sektor maritim tempatan.

Kata kunci: Data cerapan Bumi, Jalan Sutera Maritim, Asia Tenggara, kemunculan pulau, EEZ, pencemaran maritim

1.0 INTRODUCTION

Since the emergence of Maritime Silk Road (MSR) concept and its operational implementation, strengthening economic ties trough trade and investment, and cultural communication and cooperation among of the states along the route have been observed [1,2]. The new MSR initiative, led by China is believed to trigger trade and investment and eradicate territorial disputes. Maritime and territorial disputes in SEA have been evolved tensions among the states bordering the South China Sea for decades [3]. From the six major initiatives of dispute resolution in Asia, consisting of (1) Gulf of Tonkin maritime boundary agreement (2000), (2) Singapore-Malaysia Pedra Branca dispute (2008), (3) Malaysia-Vietnam continental Shelf joint submission (2009), (4) Bangladesh-Mayanmar maritime boundary dispute (2012), (5) Japan-Taiwan fisheries agreement (2013), and (6) Indonesia-Philippines maritime boundary dispute (2014) (http://amti.csis.org/maritime-disputes/) appears that, disputes are outstanding. These dispute resolution initiatives have a common need for (a) demarcating the maritime border, (b) sharing fisheries resources, (c) shelving oil and gas rights, and (d) claiming to a 200 nautical mile EEZ boundary in the disputed areas of Asia. It's well recognized that, these disputes evolved chiefly due to claiming access to marine resources, such as oil and gas by the contesting states [4]. Along with active oil and gas fields, those states are continually involved in discovering new field to meet the hydrocarbon demand (Figure 1). Inflexible stand in their claims have included negative impact on bilateral relations. Though the major focus of dispute resolution is mutual economic benefits, none of those has positioned coastal and marine resource conservation as a priority issue.

The coastal water and seabed of the SEA are based upon a diverse array of coastal and marine resources [5]. Most maritime countries have signed the Convention on Biological Diversity (CBD) and the Convention on International Trade in Endangered Species (CITES) for the sustainable management and sharing of resources. They are agreed in the implementation of these institutional arrangements (agreements and conventions) at both the national regional levels. Despite of international cooperation for sharing resources between states, there is no effective framework for sustainable harvesting of resources across the region [6]. The anthropogenic disturbances are identified as a main cause of habitat degradation and loss of marine organisms. However, there is paucity of data sources and nonexistence of periodic monitoring system with relation to marine resource distribution and status, transboundary migration of living organisms, and their living condition (water quality and pollution sources) [7–9]. Availability and sustainability of resources within contesting waters and seabed could be one of the determining factors of diplomatic negotiating objectives [10]. Delineating the maritime boundaries could be only a solution of maritime claims, not an effective implementation of sustainable management of coastal and marine resources, for which, the contesting sates claim their jurisdiction. Question is how earth observatory (EO) system and data sources can play the pivotal role in marine resource assessment and help achieving MSR goals and objectives?

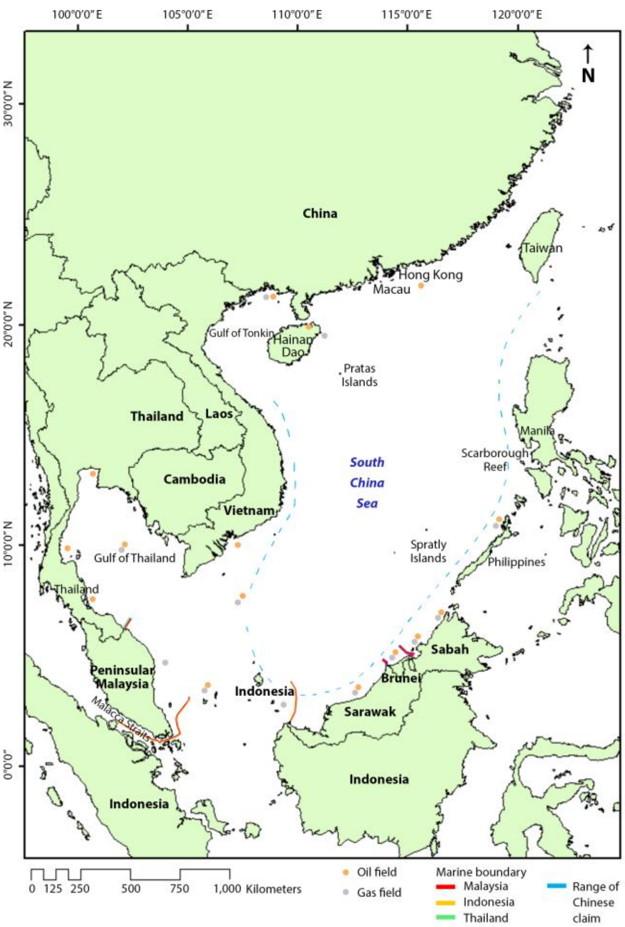


Figure 1 Location of Oil and gas fields' concentrations in the South China Sea – the main reason of territorial disputes?

Recent advances of EO system have demonstrated ability to extract marine resource information and mapping at large spatial scale which can be incorporated to the MSR initiatives through an integrated management approach [11,12]. The remotely sensed EO system has been continuously providing satellite images of long-term global observations from atmosphere to sea bottom features. MSR development initiatives should address the following questions: how do advances of EO system relative to remote sensing methods used in assessing MSR implementation strategies benefit the national and regional economy when an initiative to connect the marine biodiversity, communities and environmental changes has not been implemented at local to regional and global level? Are there adequate EO data sources that can help through providing information about (a) unchartered and emerging islands, (b) sources and causes of marine pollution, and (c) finally, a large-scale marine conservation plan development? Before developing a framework so as to choosing appropriate EO system and data dimensions, interconnectivity between the issues such as maritime activities (transportation, pollution, resource sharing) and biodiversity assessing approaches need to be developed for the sustainable development of MSR. Therefore, this paper discusses trade and marine conservation interrelated issues and challenges and the potential of using EO data for the successful development of the new MSR initiatives in SEA.

2.0 EO SYSTEM AND MSR DEVELOPMENT CHALLENGES AND OPPORTUNITIES

The coastal ecosystem made up of the coastal environment, communities (flora and fauna) and the mineral resources is interconnected and complex; the more diverse the communities and associates species, the greater the level of interdependency and interconnectivity (Figure 2). Therefore, addressing any of the issues either trade or biodiversity is inherently impacted by the maritime construct (shipping activities) and depending on one's connectivity on the other. A tipping point is that, the efficient use of satellite-based monitoring system enabling the establishment of a credible economy, broader marine ecosystem services and human wellbeing through poverty eradication (Figure 2). This probably true in maritime countries of SEA where economies are tangibly related to marine resource exploitation (fishery, oil and gas). Similar interconnectivities, illustrated in Figure 2 could be established for other impartial issues, embedding the overall connectivity and the need for an integrated and regional collaborative mechanism among the maritime states. To address these interconnected issues the satellite-based monitoring approach must underpin all aspects of the regional disputes incorporating resource sharing agreements, interrelationships, externalities (power exercised by military forces, geopolitical influences) and the actual costs and benefits of transshipment routes and activities with regard to the natural capital.

Earth observation systems are of two main classes, active and passive remote sensing. The active sensor utilizes its own energy source to illuminate the objects, and includes lidar and radar. The passive sensor uses the energy reflected by the objects and include multispectral and hyperspectral cameras, video cameras, and thermal imagers. The choice of remote sensor or combination of sensor generally depends on capability to detect target object, purpose of the project and mapping coverage – large or small. Each sensor and method, so far examined, has advantages and limitations because of inherent spatial and spectral attributes, and the surrounding marine environment that hinder the target object to be detected, that have made remote sensing research in the marine environment challenging [13–17]. However, both the active and passive remote sensing methods are potentially useful in resolving maritime transportation (trade and economy) and biodiversity conservation related issues through providing information at global and regional levels.

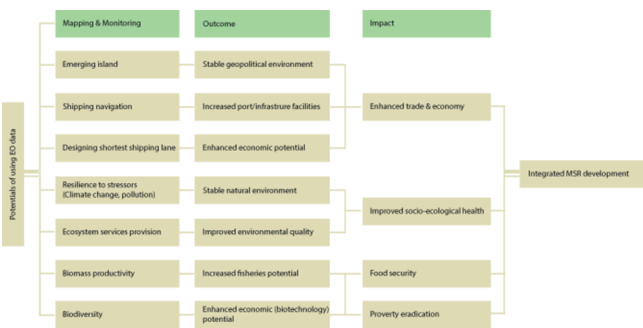


Figure 2 A framework for illustrating interconnectivity between trade and biodiversity issues, EO data flow, and MSR development data dimensions.

2.1 Trade and Economy Related Issues

2.1.1 Unchartered Emerging Island

Malaysia, one of the leading maritime countries in Southeast Asia (SEA) shares the maritime boundary, recognized by the United Nations Convention on the Law of the Sea (UNCLOS) with the Philippines, Singapore and Vietnam, and it shares both the maritime and land boundaries with Brunei, Indonesia and Thailand (Figure 3). Through the enforcement of UNCLOS, the maritime neighboring countries are entitled to share coastal waters, contiguous zones, and exclusive economic zones (EEZ), although, regional disputes are there due to disagreement on resource sharing and ambiguity in legal perspectives [3,18,19]. Territorial disputed issues encompassing the Paracel (the Pratas islands) and the Spratly islands between Taiwan, China, Brunei, Malaysia, Vietnam and the Philippines are known [20,21] (Figures 1 and 3). Moreover, there are islands that remain sunken under the sea emerge by means of mainly volcanism, but none can precisely assume how the territorial boundary dispute might escalate after the new island emergence. Question arises: should there be re-allocation of EEZ boundaries with discovery of island(s)? Early detection of these emerging islands may reduce risk of the sovereignty disputes. An integrated MSR network plan can be developed through recognizing those islands as potential EEZ for the related regional countries based on international water boundary law suits (Figure 3).

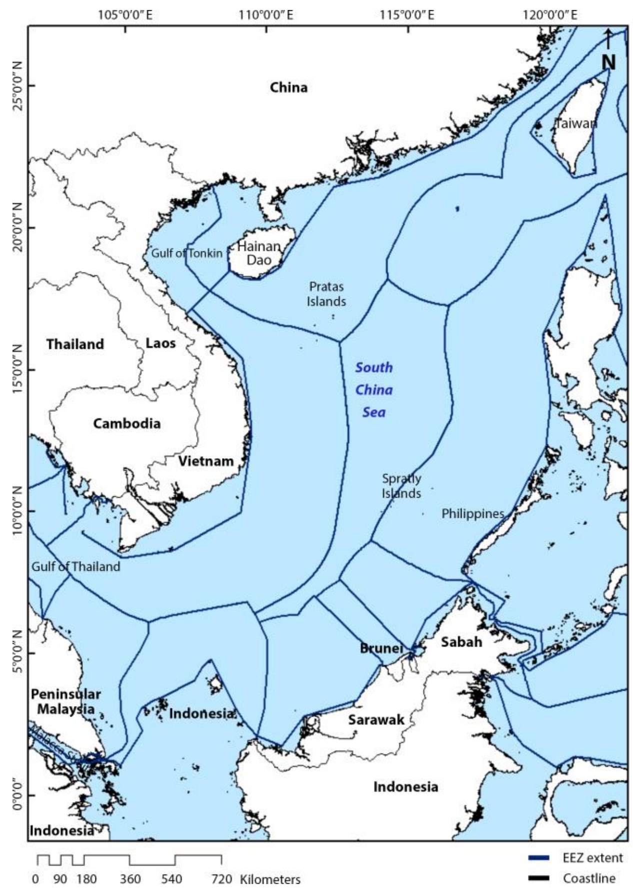


Figure 3 Extent of EEZ of countries across the South China Sea

Using the detecting ability of EO methods and/or development of EO data extraction and interpretation approaches can provide necessary information related to which state should be under jurisdiction of the emerging and unchartered islands.

2.1.2 Shipping Route, Navigation and Port Facilities

With the economic integration through MSR initiatives, maritime transportation which relies on shipping lanes has increased traffic congestion and risk of shipping accident in this region. Rapid economic growth has raised concern regarding energy security. Coastal states and MSR countries need to place themselves regarding port facilities to provision for this growing trade and optimize their economic benefits. The Straits of Malacca have become the most important shipping in SEA for international and local trade (Figure 4). China had to import great bulk of oil (three-quarters) using single check point waterways, the Straits of Malacca to balance its demand and supply [22]. Heavy traffic congestion has occurred due to increased transshipment of oil and cargo vessels (more than 60,000 ships per year), traversing shallow and narrow channels of the Straits. This has increased frequency of shipping accidents [22] and disposal of hazardous materials. While the Straits are rearing renewable natural resources including mining and natural gas, rich in marine diversity including seagrass meadows, corals, aquaculture, tourism, the shipping lanes developed for the straits are less concerned regarding biodiversity management and conservation issues compared to economic gains.

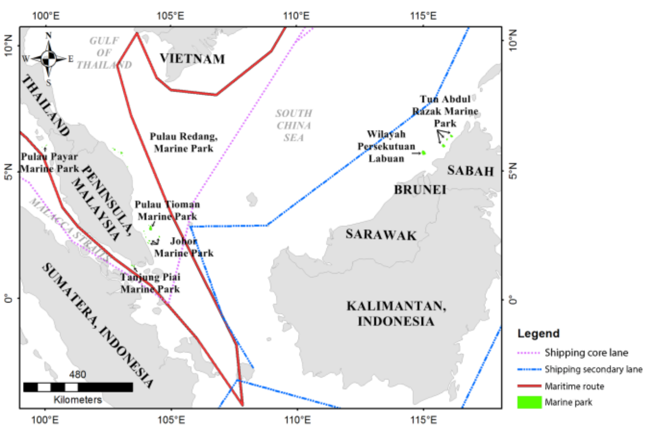


Figure 4 The Straits of Malacca, Malaysia

Satellite data can be used in designing port facilities and developing sea traffic management systems. Satellite-based database allows for monitoring actual traffic condition that can reduce risk of ship collision [23] and generate real time bathymetric data that can ensure shipping navigation and traffic safety. Evaluation on relative efficacy between multispectral and acoustic remote sensing methods can help the project manager to choose the appropriate method. Ocean bathymetric data can be used as proxy of shipping navigation through providing data on sea floor depth at required spatial and temporal scale.

Microwave radar is potentially useful in detecting oil spills and ships for a larger search areas compared to optical EO sensors [24,25]. There are a number of potentially useful satellite sensors for detecting debris in the open ocean [26].

2.1.3 Designing Shortest Shipping Lane

For distribution of goods in containers in the fuel efficient trade context, shortest routes are preferred that traverse the EEZ areas. To trade China within SEA, has to follow longer shipping route, linking the mainland of China with ports throughout the Middle East, traversing the South China Sea. The shortest route, through seaport of Riga (Latvia) has been suggested for China to trade within the European Union [27]. Similarly, the shortest route for the MSR could be designed using EO data sources.

2.2 Biodiversity Conservation Related Issues

2.2.1 Resilience to Stressors

Climate change due to sea level rise, blue carbon emission and changing temperature, from costal habitat degradation to impacts upon migration of marine organisms have been explicitly discussed in the literature [11,28–33], but the concept of integrating maritime transport and resilience to climate change stressors are relatively new [34]. The maritime transport activities of Asian countries assumed to affect CO_2 emissions [35] and consequently resilience to climate change. Mining activities are often identified as a source of marine pollution as evident in the waters of the Straits of Malacca [36]. Sea waters absorbed around 25% of anthropogenic CO_2 due to industrialization and subsequently increased ocean acidity by 26% [37]. Ocean acidification adversely affects seawater chemistry, thereby marine organisms, reduces their growth and survival, and increases of ocean acidity decreases its capacity to absorb CO_2. The MSR mechanism has not addresses ocean acidification and blue carbon sequestration role till-to-date and there is no appropriate EO system to specifically monitor changes in acidification.

Remote sensing methods can be used in monitoring ocean acidification [37] and blue carbon (http://water.usgs.gov/nrp/blue-carbon/nasa-blue-cms/index.html) changes as evident from on-going project activities. The visible broad-band of AVHRR, MODIS is found effective for global calcium carbonate measurements, and SeaWiFS for coccolithophore calcite concentration estimation. Blue carbon sequestration from biomass estimates [Figure 5; 38] is another important estimate that indicates marine ecosystem health [39], but less studied area. As the existing methods have pros and cons [40,41], further study can address the issues to precisely estimate coefficients for ocean acidification and blue carbon emission at global and regional scale.

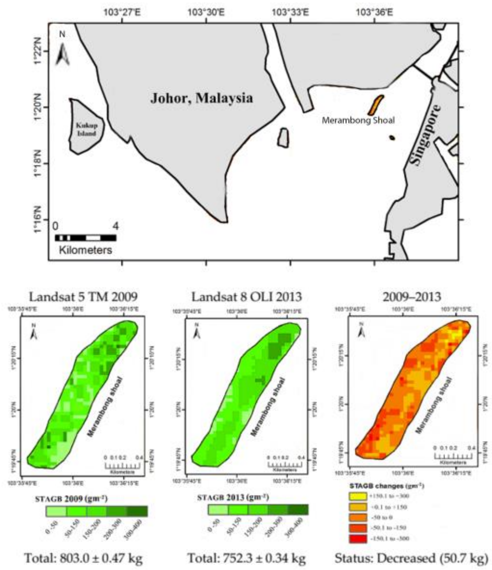


Figure 5 Landsat (EO data) used to identify seagass biomass distribution [38], can also be used to estimate blue carbon sequestration

2.2.2 Ecosystem Service Provisions

What is a wise use of coastal and marine resource? This perennial issue, always controversial due to conflicting interests among the maritime countries, has in the last decade tended to be clothed in the context of 'sustainable development'. The rapid breakthrough of this concept in socio-political and scientific spheres has brought to our attention the dependence of human survival and well-being upon coastal ecosystem services [42–46], as well as the susceptibility of ecosystems to geopolical influences. Beyond the power clashes and contesting maritime claims, the over-exploitation and uncontrolled harvesting of marine resources particularly fishery are imposing serious concerns on the health and security of the marine ecosystem [47]. On the marine biotechnology has the potential to meet the demand of global challenges such as sustainable food supplies, energy security and marine ecosystem remediation [48–50].

Marine Protected Area (MPA) may provide required ground-truthing data on biodiversity related issues at local to regional scales (Figures 1 and 2). Although remote sensing-based studies mostly concentrated inventories of mangrove [51], seagrass meadow [52], coral [53] and their physical environment, but little attemp were made for the valuation of their ecosystem services and explore the linkages to the shipping activities at the seascape level. The wider-viewing sensor SeaWIFS with seven multi-spectral bands across the visible and near-infrared regions is one of the most promising ocean color sensor and has proven applications including monitoring phytoplankton, algae, and water quality on regional scale (Figure 5). Improvement of EO data analysis methods using multi-spectral Landsat imagery with moderate resolution (30 m) [13], Quickbird and IKONOS with high resolution (<3 m) is a topic of on-going research on change detection in seagrass and coral habitats and for other applications.

3.0 CONCLUSION

Regional cooperative actions with a satellite-based monitoring system, economic valuation of regional fisheries and MSR regional thinking can be effective approaches for the sustainable management of marine resources [54]. Despite SEA states have proven willing to manage and resolve their disputes indicated by participation in agreements, the baseline scenario, structured EO data acquisition and interpretation scheme, emerging island, maritime activity implication, broad-scale motoring data deficiency on marine resources/diversity are sever constraints in this region. An integrated and holistic approach for satellite-based marine resource assessment, monitoring and management is essentially needed. This paper critically analyses the interconnected maritime activities and sustainable marine biodiversity management issues, potential usefulness of satellite data that could enable a framework development and thereby ensure the success of regional MSR initiatives. The concept discussed in this paper provides a subjective approach for defining the interconnectivities of MSR activity and biodiversity conservation problem and utilises this dependent information to engage suitable remote sensing method. The knowledge gaps must be identified and prioritized [55–57], although there may be quality EO data available for some areas before adopting a suitable remote sensing system that should incorporate marine ecosystem processes and maritime actions.

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