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Repercussion of meagre flow of the lower Indus River

Sher Khan Panhwar[1]

Abstract

This study was intended to gauge seawater penetration in the lower Indus region and an overview on economic, social and ecological snags including (i) agriculture which is occupation of over 60% population residing in the Badin, Sujawal and Thatta districts of Sindh (ii) The escalating freshwater scarcity is leading to either displacement of populations or forcing them to live below poverty line due to the diminishing cultivable land (iii) People switched from agriculture profession to fisheries (iv) The lack of access to quality drinking water and the presence of unsuitable underground water pose significant health hazards (v) No-water in lower Indus region has damaged river and estuarine ecosystem that provide geo-ecological services (vi) Since long meagre dischargement of sediment reached toward delta permitted seawater to penetrate thousand acers of cultivable land into saline soil.

The most affected dehs of Thatta district include three Talukas Mirpur Sakhro (14 Dehs), Ghorbari (7 Dehs) and Keti Bunder (31 Dehs). Three dehs Milko, Pirpathai and Pumbri of Mirpur Sakhro are completely under sea water and out of agriculture. Sea water inundation has badly affected Ghorabari Taluka over thirty-two-thousand-acre land of seven Dehs are now briny. Thirty-one Dehs of Taluka Keti Bunder are completely barren. Badin district is divided in two talukas (Badin and Shaheed Fazil Rahu) and ten Dehs namley, Babralo, Dharan, Warayo, Sando, Patiji, Thath, Siantri, Khudi, Palh, Ahmed Rajo, out of which three dehs Babralo, Siantri and Ahmed Rajoare completely barren in a limited period of (2008-2018). Overall outcomes of this study reveal that southernmost region of Sindh encounter rampant seawater penetration. Hence, the construction of solid infrastructure such as coastal highways, dense forestation,

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reinforcement of coastal banks in affected areas, and ensuring continuous freshwater flow towards lower region imperative.

Keywords: Seawater penetration, increased uncultivable land, reduction in fisheries potential, lower Indus riparian.

Introduction

Indus River is a principal river of Pakistan stretches from Himalayan Mountain in the north to the dry alluvial plains of Sindh, Pakistan in the south and finally drains into the northern Arabian Sea. Indus River is the only source of agriculture cultivation, drinking water and maintain Indus delta (estuarine area) where it creates a unique ecosystem that support innumerable aquatic organisms. People living in lower Sindh Indus belt depending on agriculture and fishing or fisheries associated activities. However, since last few decades upstream water development has created economic, social and environmental problems. Coincides climate is not uniform over the Indus River basin it varies from temperate, to subtropical arid and semiarid on the plains of Punjab and Sindh provinces. Additionally, in low lying areas, annual precipitation typically varies 100 to 500 mm, while mountain slopes receive a maximum 2000 mm.[2] rainfall annually. All these factors created severity and destructed livelihood of millions of people depending on fisheries or fisheries related activities living on lower Indus area. Reduced river flow, widespread deforestation, intrusion of seawater, rising sea levels, and pollution constitute the primary factors contributing to the degradation of the Indus Delta. These mangroves forests are can severely protect us from tsunamis and other natural disasters and can help in fisheries productivity. Key factor influencing the oceanographic processes of the Indus River estuary is the fluctuations in Indus River flow since the variations in fluvial discharge have a direct impact on seawater salinity that can be considered as trigger of ocean / organism life. Indus delta accounted as the sixth largest delta of the, structurally it is fan-shaped textured by huge amount of silt drifted from high mountains reaches through river Indus.[3] In the present scenario the delta covers an area

[2] FAO, 2011. Indus River Basin: Irrigation in Southern and Eastern Asia in figures – AQUASTAT Survey – 2011: 1-14

[3] Abbasi, A. G., 2002, “Restoration of Sindh’s Primary Rights over River Indus”, 18th Convention of SANA, Cherry Hill, New Jersey, July 4-7.

of about 600,000 hectares that is further disseminated in 17 major and several minor creeks, swampy and mangrove forests.[4] In the past, the Indus River was one of the largest river sediments in the world. In the past five to seven decades, it transports 185 BCM of freshwater annually and about 400 MT of sludge/slit were carried to downstream.[5,6] The lives of the peoples living near the lower Indus River were mainly dependent on these resources, nevertheless, the present circumstances are deeply disheartening, with conflicts having erupted as a result. Physically, Indus River estuary can be defined as a partially-mixed with arid sub-tropical coastal climate influence by monsoonal cycle. [7] Further monsoonal cycle can be defined as May-September (summer) south-west monsoon that is highly influential on the physical and environmental scenarios whereas November-February (winter) as north-east monsoon are the triggers of the area. [8] In recent years, there has been a growing emphasis on the issue of seawater intrusion affecting lower Indus riparian areas. [9] [10] This study was aimed to summarize, analyze and address socioecological concerns of the southernmost part of Sindh province.

[4] Meynell, P. and Qureshi, T., 1993, "Sustainable management of mangroves in the Indus Delta, Pakistan", In David, T. (ed) *Towards the Wise Use of Wetlands*, Ramsar Bureau, Gland.

[5] Nasir, S.M., Akbar, G., 2012. Effect of River Indus flow on low riparian ecosystems of Sindh: a review paper. Rec. Zool. Surv. Pak. 21, 86–89.

[6] Wang, J., Li, Li., He, J., Kalhoro, NA., Xu, D. 2019. Numerical modelling study of seawater intrusion in Indus River Estuary, Pakistan, Ocean Engineering, 184, 74-84.

[7] Abbasi, A. G., 2002, "Restoration of Sindh's Primary Rights over River Indus", 18th Convention of SANA, Cherry Hill, New Jersey, July 4-7.

[8] Banse, K., 1984, "Overview of hydrography and associated biological phenomenon of Arabian Sea off Pakistan", *Marine geology and oceanography of Arabian Sea and the coastal Pakistan*, Haq BU, Milliman J (eds). VNR/SAE Co. New York, 271-303.

[9] Khaskheli, N., Kalhoro, NA., Wang, J., He, J., Xu, D., Tunio, GR., Shahani, K., Salih, Hussain, FS . 2018. Impacts of tidal link drain, along the coastal areas of districts Badin and Sujawal in Indus deltaic region, Sindh Pakistan", *MAUSAM*, 69 (4), 535–542.

[10] Wang, J., Li, Li., He, J., Kalhoro, NA., Xu, D. 2019. Numerical modelling study of seawater intrusion in Indus River Estuary, Pakistan, Ocean Engineering, 184, 74-84.

Methodology and data sources

Seawater penetration data of respective dehs, taluka and district-wise was obtained from district management offices. Related to this some of the information was obtained from the available literature. The flow and upstream water availability record was acquired from irrigation department. Ecosystem degradation and fisheries associated information was also obtained from published literature e.g. reports, review papers and research articles in renowned newspapers and research journals.

Results and discussions

In this study, various data sources were used to draw meaningful conclusions and to discuss the burning issues of the lower Indus River.

Indus River flow upstream from Kotri Barrage

The lowest water flow (128,711 cf) of Indus River from Kotri Barrage was recorded in 2010 and the highest 377,829 cf noted in 2016, whereas (335,225) flow was noted in 2010-2018 (Fig. 1).

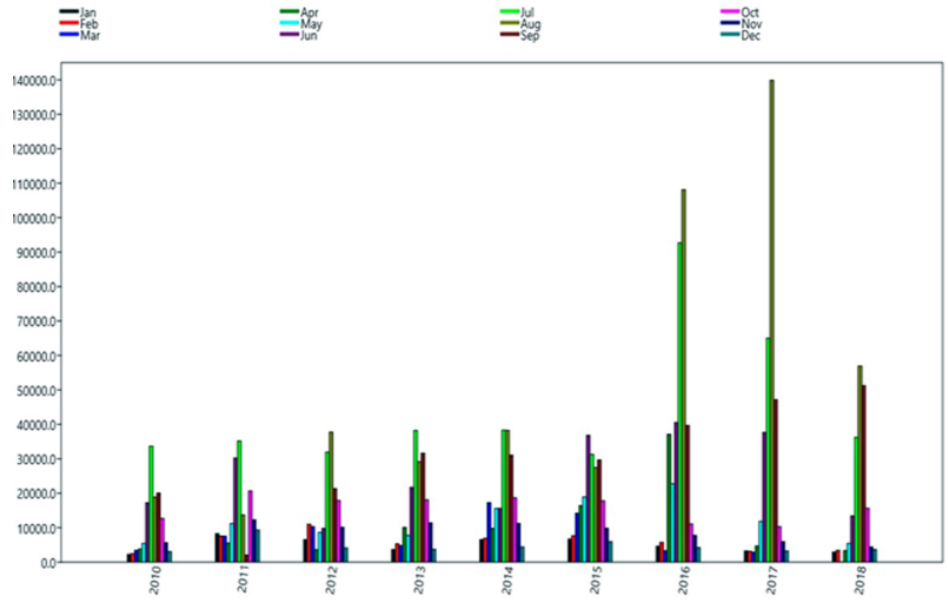

Figure 1. Month-wise water record at Indus River from Kotri Barrage

Data of upstream flow of river Indus from Kotri barrage was recorded as in 2010. However, decal record of meager freshwater flow in to downstream Indus River carries water not for agriculture but

drinking and other use as well. Downstream freshwater water flow from 2010-2015 (Fig. 2) validates that insignificant water flow during six-year period has transported very low siltation up to the delta region that can only restrain sea water inundation.

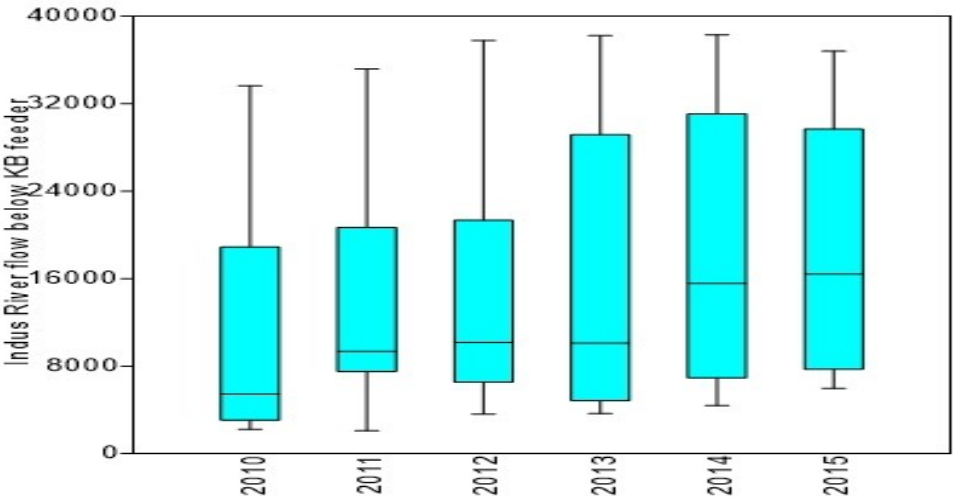

Figure 2. Box-plots showing yearly average upstream flow of the Indus River at Jamshoro

Seawater intrusion in Thatta District

Thatta district is comprises of three Talukas Mirpur Sakhro (14 Dehs), Ghorabari (7 Dehs) and Keti Bunder (31 Dehs). Three dehs Milko, Pirpathai and Pumbri of Mirpur Sakhro are completely under sea water and out of agriculture. Sea water inundation has badly affected Ghorabari Taluka over thirty-two-thousand-acre land of seven Dehs are now saline. Thirty-one Dehs of Taluka Keti Bunder are completely covered by sea water penetration (Fig. 3).

Periodic data of sea water intrusion elucidate the area of three main talukas of District Thatta inundated since last two decades. It can be assumed that if the rate of sea water intrusion steadily occupy agriculture land of Thatta district will severely damage millions of the residents.

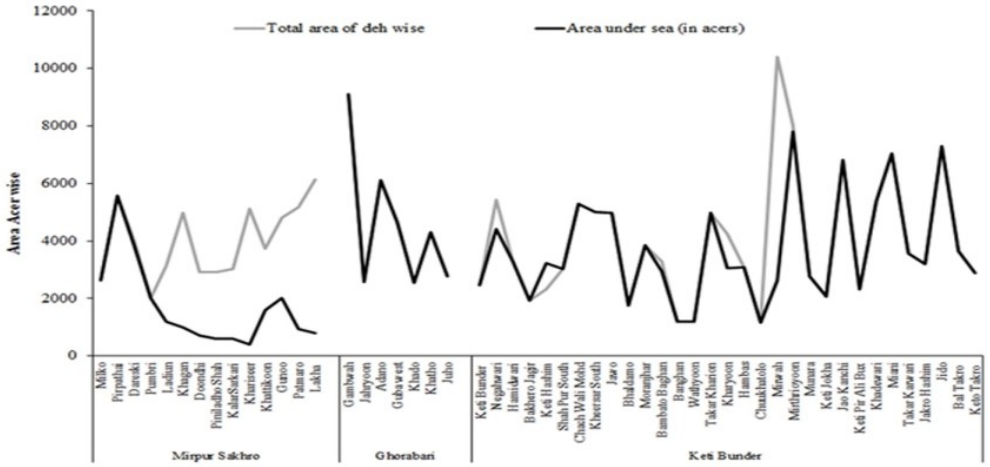

Figure 3. Three talukas of the Thatta district encounter gradual influence of seawater penetration

Seawater Intrusion in Badin District

Badin district is divided in two talukas (Badin and Shaheed Fazil Rahu) and ten Dehs namely Babralo, Dharan, Warayo, Sando, Patiji, Thath, Siantri, Khudi, Palh, Ahmed Rajo, out of which three dehs Babralo, Siantri and Ahmed Rajoare completely engulfed by sea water penetration. In this study decal (2008-2018) data of sea water converted agricultural land of Badin District as saline soil. This land is now out of agricultural cultivation (Fig. 4).

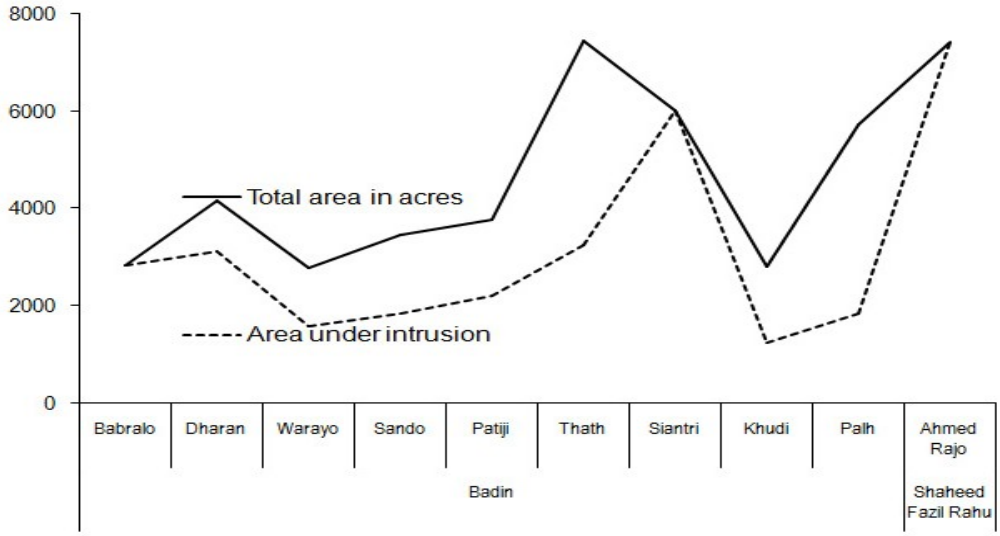

Figure 4. Agricultural land of Badin District encapsulated by the seawater intrusion

Hence, this rise in air temperature leads to elevated sea surface temperatures, altering the aquatic ecosystem and its inhabitants.

Undeniably, meagre flow of the Indus River troubling deltaic area but climate change imposing its impact to the coastal region by changing sea-level. This is due to industrial revolution is the only cause of global warming and sea-level rise. Besides, burning coal and oil and cutting down forests will increase the heat in the atmosphere, which will return to our planet[11]. Therefore, this rise in air temperature leads to elevated sea surface temperatures, altering aquatic ecosystem and inhabitants (Cazenave and Llovel, 2010; Levitus et al., 2009) [12] [13]. Persistent Ocean warming is huge, and this thermal expansion is the main driver of global sea-level rise in the 75-100 years after the Industrial Revolution (Cazenave and Llovel, 2010).

Conclusion

Based on the Indus River water data acquired from the Irrigation Department, Government of Sindh and non-cultivable land record of Thatta and Badin districts reveals that the situation has overwhelmed population depending on the agriculture to displace toward other areas for the sake of livelihood. Besides, significant reduction in fish catch, fishers switch to other professions / activities. The overall situation required serious attention of the managers, stakeholders to take reasonable measures to prevent seawater intrusion by constructing solid structures like coastal highway, protected bank along affected areas and persistent freshwater flow will help to deposit silt and increase strength of deltaic region.

[11] Hansen, J., R. Ruedy, M. Sato, and K. Lo (2010), Global surface temperature change, Rev. Geophys.,48, RG4004.

[12] Cazenave A, Llovel W. 2010. Contemporary sea level rise. Ann Rev Mar Sci. 2:145-73.

[13] Levitus, S., Antonov, J.I., Boyer, T.P., Locarnini, R.A., Garcia, H.E., Mishonov, A.V. 2009. Global ocean heat content 1955–2008 in light of recently revealed instrumentation problems, Geophysical Research Letters, 36, l07608

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Piracy in Southeast Asia during the COVID-19: Exploring Regional Anti-Piracy Strategies and China's Involvement

Liang Luo*

Abstract

Recent years have witnessed a pessimistic maritime security environment and an increasing emergence of non-traditional security threats in the Southeast Asian Waters. In early 2020, although the covid-19 outbreak and quickly spread to the world, piracy was still rampant in the Southeast Asian waters. Thus, the fight against piracy became a major challenge for maritime governance. The covid-19 pandemic was a global trigger for weak economic growth and social conflicts. This paper collects the piracy information reported by the International Maritime Organization (IMO), the International Maritime Bureau (IMB) and other institutions. After that, it sorts these reports from different perspectives. Then, it demonstrates the change trend of piracy such as behavior patterns, criminal areas and criminal characteristics. In addition, the paper also suggests that China should actively participate in international anti-piracy cooperation in this region and joins hands with other states in this region and international organizations. In this way, they can prevent and combat crimes, for instance, piracy and armed robbery against ships, and maintain peace and stability in Southeast Asia.

Keywords: *covid-19; Southeast Asia; pirate; anti-pirate mechanism; China's Involvement*

1. Introduction

Since the 21st century, the threats from non-traditional maritime security field have been on the rise, to combat the crimes of

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pirates and armed robbery against ships is a major challenge for maritime governance.

In early 2020, the covid-19 out broke and swept the world, the pandemic was a global trigger for weak economic growth and social conflicts. Many industries were swaying or directly discontinued. As a result, inhumane or illegal acts have been increasing.

The shipping business is the cornerstone of the global supply chain and international trade. Asia is a number one region in the world in the case of development potential and dynamic growth in maritime transportation market. Meanwhile, the Asia-Pacific region is also a region with converging interests of major powers, prominent challenges to ocean, sovereignty disputes and conflicts between the countries in this region, and long-term intense geopolitical game. Therefore, it is extremely difficult to achieve maritime governance there. The ocean is a cradle of life, a link to the world, a platform for development, and an important field for building a community with a shared future for mankind. Based on an observation and analysis of the current situation and hazards of piracy in the Southeast Asian waters, this paper intends to examine the efficiency and deficiency of international and regional anti-piracy mechanisms. After that, it discusses several major issues that need to be resolved by the relevant countries and regions.

Definition of piracy and selection of data sources

1.1 Definition of piracy

When analyzing piracy, the scholars specialized in international law often refer to Articles 15-19 of the 1958 Convention on the High Seas, Articles 100-107 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), and the 1988 Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA Convention).[2] Some scholars also suggest that, in addition to the above-mentioned laws, there should be an inclusion of the provisions of the 1988 Protocol for the Suppression of Unlawful

[2] Nong Hong. “On the Construction of Non-traditional Maritime Security Cooperation Mechanisms in the South China Sea Region: A Perspective Based on the Analysis of Piracy and Maritime Terrorism Issues.” *Asia-Pacific Security and Maritime Affairs*, 2018, pp.36-52.

Acts (SUA) against the Safety of Fixed Platforms Located on the Continental Shelf, the 1988 SUA Convention and its 2005 Protocol, the provisions of the CMI Model National Law on Acts of Piracy and Maritime Violence, etc.[3] IMO and IMB are the international maritime security bodies whose work are directly concerned with combating piracy. Currently, they use a common definition of "piracy" and "armed robbery against ships" provided in the articles of UNCLOS and the Code of Practice for the Investigation of the Crimes of Piracy and Armed Robbery against Ships.[4]

According to Article 101 of the UNCLOS, piracy have the six characteristics: (1) it is occurred on the High Seas, which means that it is not occurred in any other region under any State's jurisdiction; (2) it is not committed by ordinary persons but by the crew or the passengers in an aircraft or a ship; (3) the aircraft or ship must be owned by private person rather than any other entity or person; (4) it is committed against other ship, aircraft, and persons or property on board such ship or aircraft; (5) it includes any unlawful acts in the form of violence, detention or destruction; (6) it is a kind of voluntary participation with the intention of committing piracy, or inciting or facilitating piracy.[5]

The Regional Cooperation Agreement on Combating Piracy and Armed Robbery against Ships in Asia (ReCAAP) is the first intergovernmental agreement in Asia for further enhancing cooperation in combating piracy and armed robbery against ships.

[3] Dan Liu. "Piracy Governance from the Perspective of the Law of the Sea." *Exploration and Free Views*, 2011, pp.19-21.

[4] Feijun Huang. "International Practice in and China's Response to Combating Piracy and Armed Robbery against Ships in the Southeast Asian Waters." *Journal of Boundary and Ocean Studies*, 2018, p.50; "IMB Piracy Reporting Center," accessed at July 3, 2023,

[5] According to Article 101 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), piracy consists of any of the following acts: (a) any illegal acts of violence or detention, or any act of depredation, committed for private ends by the crew or the passengers of a private ship or a private aircraft, and directed: (i) on the high seas, against another ship or aircraft, or against persons or property on board such ship or aircraft; (ii) against a ship, aircraft, persons or property in a place outside the jurisdiction of any State; (b) any act of voluntary participation in the operation of a ship or of an aircraft with knowledge of facts making it a pirate ship or aircraft; (c) any act of inciting or of intentionally facilitating an act described in subparagraph (a) or (b). "United Nations Convention on the Law of the Sea," United Nations. (1982). United Nations Convention on the Law of the Sea. United Nations.

The Agreement took effect in November 2006. As at July 2023, it has 21 contracting parties (14 Asian countries, 5 European countries, Australia, and USA).[6] In addition to making a definition of pirate according to Article 101 of the UNCLOS, ReCAAP also makes a definition of armed robbery against ships. According to the resolution A.1025 (26),[7] the Code of Practice for the Investigation of Crimes of Piracy and Armed Robbery against Ships, accepted by the 26th Assembly of the IMO, makes a definition of "armed robbery against ships" that is very close to the wording used in Article 101 of the UNCLOS.[8]

As mentioned above, although the UNCLOS is the most important treaty ratified by South-East Asian countries, its definition of piracy is limited to the high seas and is generally not applicable to the piracy in the South-East Asian waters. In contrast, the definition of piracy and armed robbery against ships in ReCAAP can be extended to the application of crimes occurred in the Southeast Asian waters. However, Indonesia and Malaysia have not yet ratified accession to ReCAAP because of their consideration of special interests. According to ReCAAP, the waters as the place where the crime of armed robbery against ships is committed shall be under the jurisdiction of relevant state. To a certain extent, this provision is a remedy to the insufficient definition of pirate made in the Convention and the Agreement. It also contains an addition of the means of the criminal behavior. In this paper, the terms piracy, maritime piracy and armed robbery against ships are alternately used, and collectively referred to as "piracy offences" or "acts of piracy" in a broad sense, which includes both robbery attempt and robbery completion.

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[6] "What is Piracy and Armed Robbery Against Ships and What Should You Do If You Encounter an Incident? " Accessed at July 7, 2023. About ReCAAP Information Sharing Centre. (n.d.).

[7] "Resolution A.1025(26) (Annex, paragraph 2.2)," adopted on 2 December 2009. e code of practice for the investigation of crimes of piracy and armed robbery against ships. (2010).

[8] According to the definition, "armed robbery against ships" means any of the following acts: (1) any illegal act of violence or detention or any act of depredation, or threat thereof, other than an act of piracy, committed for private ends and directed against a ship or against persons or property on board such a ship, within a State's internal waters, archipelagic waters and territorial sea; (2) any act of inciting or of intentionally facilitating an act described above.

1.2 Scope of the Region

In 1962, the Conference of Southeast Asian Geographers was held in Kuala Lumpur, Malaysia. It was agreed at the conference that "Southeast Asia" can be generally used as a geographic name for the region.[9] In the South-East Asian region, there are 10 member states and 1 observer state (Timor-Leste) of ASEAN. All the 10 countries, except Laos, are coastal or island states. Bordered by the East Asian continent to the north, Australia to the south, the Pacific Ocean to the east, and the Indian Ocean to the west, South-East Asia is adjacent to Bangladesh and India. Thus, it is a bridge connecting three continents (Asia, Africa, and Oceania) and two oceans (the Pacific Ocean and the Indian Ocean). In the region, there is a strait called the Straits of Malacca between the Sumatra Island and Malay Peninsula. Although it is only about 900 kilometers in length, it is a major maritime route for trade between the East and the West.

The IMB published data on piracy and armed robbery in the region. In such data for statistics, South-East Asia includes Indonesia, the Malacca Straits, Malaysia, the Philippines, the Singapore Straits and Thailand, whereas China and Vietnam are included in East Asia. When it comes to the ReCAAP, the countries and regions covered are mainly North Asia (China), South Asia (the Arabian Sea, Bangladesh, the Bay of Bengal, and India), and South-East Asia (the Andaman Sea, the Indian Ocean, Indonesia, Malaysia, the Pacific Ocean, the Philippines, the South China Sea, the Sulawesi Sea, the Malacca and Singapore Straits, Thailand, and Vietnam). Relatively speaking, the "South-East Asian Seas" covered by the Agreement are wider than that covered in the data published by the IMB.

1.3 Source of data

The IMB set up the Piracy Reporting Centre (IMB-PRC) in Kuala Lumpur, Malaysia. It is the sole non-governmental organization in the world that manually receives and immediately disseminates information on piracy and armed robbery 24 hours a day. The ReCAAP also set up an "Information Sharing Centre" (ReCAAP-ISC) in Singapore. It is used to strengthen regional cooperation by information-sharing, capacity-building and other measures. As an intergovernmental organization, the IMO has the Global Integrated

[9] Zhi Liu. “Introduction to Southeast Asia,” 2007. Accessed at July 7, 2023.

Shipping Information System (GISIS). It collects all kinds of information through various channels, and immediately publishes and reports information through the modules of piracy and armed robbery against ships contained in GISIS. The information from IMB-PRC and ReCAAP-ISC is also integrated into GISIS. This paper uses the reports published by IMB-PRC and ReCAAP-ISC between 2018 and 2022 as the main source and the relevant data contained in the reports published by the IMO as supplementary source for statistical data.

2. Analysis of the piracy posture in the South-East Asian waters

Since the end of Cold War, world trade has developed rapidly, the Straits of Malacca and Singapore (SOMS) in the South-East Asian Waters have shown increasingly important roles as international trade routes. Among the threats in the field of non-traditional maritime security on a global scale, crimes of piracy have also begun to gradually increase in number. Overall, modern pirate activities mainly occur in five regions, namely, the West African coast and Somali waters, the Red Sea and the Gulf of Aden, the Bay of Bengal, the South-East Asian waters, and the Caribbean Sea between South and Central America.[10] At its peak between 2000 and 2004, there were an average of 350 to 450 incidents of piracy per year, increasing the cost of international trade by $7-12 billion per year.[11] In the South-East Asian region, piracy has also become more prevalent after the 1998 financial crisis. In 2000, there was 469 piracy cases reported in the world, and 242 cases (52%) occurred in the South-East Asian waters.[12]

[10] Zhen Yang, Jie Zhang. “Piracy and Comprehensive Maritime Governance from the Perspective of Maritime Silk Road.” *Report on China’S Non-Traditional Security Studies (2015-2016)*. Beijing: Social Sciences Academic Press.2016.

[11] ReCAAP. “Incident Alert Sea Robbery Incidents in the Singapore Strait,” accessed at July 13, 2023.

[12] “The Realities and Legends of Pirate,” September 25, 2002. http://old.lifeweek.com.cn//2002/0925/644.shtml

Table 1 Changes in piracy worldwide (2017-2022)

Year		2017	2018	2019	2020	2021	2022
Total	IMB	180	201	162	195	132	115
	IMO	203	223	193	229	172	131
Data Gap		23	22	31	34	40	16

Note: This table is made by the author, based on the 2022 Report on the Piracy and Armed Robbery Against Ships published by the IMB and the 2017-2022 Reports on the Piracy and Armed Robbery Against Ships published by the IMO.

Although there are some discrepancies in the data released by IMB and IMO, both of them showed that in the year following the outbreak of covid-19 at the beginning of 2020, there was a significant increase of piracy in the world which can be seen in Table 1. The data reported by the IMB and the IMO showed that there was a respective increase of 20% and 19% in 2020 compared to 2019 in terms of the number of piracy crime in the world.

In the relatively long period, the number of pirate attacks in the world has generally been on the decline due to the joint efforts of the international community to combat piracy, mainly due to the reduction of pirate activities in the waters of the Gulf of Guinea. However, incidents of piracy and armed robbery against ships have continued to frequently occur in the Asian region and in the waters of South-East Asia, especially in the key strategic sea lanes such as the SOMS.

Table 2 Changes in Piracy Behavior in Asia (2017-2022)

Year	2017	2018	2019	2020	2021	2022
Total	102	76	83	97	82	84

Note: This table is made by the author, based on to the 2022 Report on Piracy and Armed Robbery Against Ships in Asia published by ReCAAP.

Data from different sources showed that there was a significant increase of piracy offenses in both the world and Asia in 2020 compared to the years before the outbreak of covid-19. As shown in Table 2 and Table 1, there was 97 cases of piracy offenses in Asia in 2020, an increase of 14% from 2019. A further observation showed that there was a peak of piracy in the Southeast Asian Waters in the six-month period after the COVID-19 outbreak. According to the report for the first half of 2020 published by ReCAAP-ISC, a total of 51 piracy incidents were recorded in the Asian waters, which was nearly

twice as many incidents as were reported during the same period in the year prior to the outbreak of covid-19 (28 incidents).[13]However, a downward trend began after 2021, and the global number of piracy incidents in 2022 fallen to the lowest in the three years since the outbreak of covid-19. This decline trend of piracy incidents is related to the global economic downturn.

Table 3 Piracy in the South-East Asian Waters (2020-2022)

Year	Region and country											Total
	the Andaman sea	Pacific Ocean	Indonesia	Malaysia	Pacific	the Philippine	the South China Sea	the Straits of Malacca and Singapore (SOMS)	the Sulawesi Sea	Thailand	Vietnam	
2019	-	-	23	8	1	7	1	31	2	-	2	75
2020	-	-	22	3	-	13	4	34	1	-	6	83
2021	-	-	13	1	-	11		50	-	-	2	77
2022	-	-	10	2	-	4	1	55	-	-	2	74

Note: This table is made by the author, based on the 2022 Report on Piracy and Armed Robbery Against Ships in the Asia published by ReCAAP.

Table 3 shows three facts. First, after the outbreak of covid-19, piracy in the Southeast Asian waters reached 83 cases in 2020, accounting for more than 80% of number in the Asian region (97 cases), making the Asian waters a region with high-risk of piracy. Second, although the number of piracy incidents in Southeast Asia has been reduced to the level before the outbreak of covid-19 in 2021 (77 cases) and 2022 (74 cases), the data published by the IMB still showed that such number accounted for 58% and 64% of global piracy incidents, respectively. This high proportion proves that the Southeast Asian region is still a geographic concentration of the

[13] ReCAAP.“Piracy And Armed Robbery Against Ships In Asia (January-June 2020).”

global piracy incidents. Third, the SOMS are the main places of piracy in the Southeast Asian waters. And particularly in 2021 and 2022, the piracy incidents occurred in the said two straits accounted for more than 50% of that in the Southeast Asian waters.

Table 4 Changes in piracy in the SOMS (2017-2022)

Year		2017	2018	2019	2020	2021	2022
Total	IMB	4	3	12	23	36	38
	ReCAAP	9	8	31	34	50	55
Data Gap		5	5	19	11	14	17

Note: This table is made by the author according to the 2022 Report on Piracy and Armed Robbery Against Ships in Asia published by ReCAAP and the 2022 Report on Piracy and Armed Robbery Against Ships published by IMB.

The data published by both the IMB and ReCAAP-ISC show an obvious trend: there has been a consecutive rise in the number of piracy incidents in the Straits of Singapore and Malacca in recent years, as shown in Table 4. The 38 piracy incidents in the Straits of Singapore in 2022 was a new record for the region since 1993 when the IMB began to publish report of piracy incident. [14] Further observation shows that ReCAAP-ISC has paid attention to the on-going incidents of piracy in the SOMS . Thus, it issued Incident Alert No. 02/2023 on June 13th, 2023, advising all ships to be vigilant when passing through the SOMS. Meanwhile, ReCAAP-ISC also recommended that littoral states should strengthen their patrols and law enforcement in the region. The warning instrument issued by ReCAAP-ISC showed that 34 incidents of piracy have been reported in the SOMS in the past serval months of 2023.[15]

Due to the attention and efforts of governments and international organizations, naval escorts and reconnaissance aircraft deployments have had a deterrent and combating effect on piracy worldwide. In 2008, four resolutions on the situation of piracy in Somalia were successively adopted at United Nations Security Council (UNSC), of

[14] Yuchi Cao, Guoping Zheng. “An Analysis of the Global Piracy Incidents in 2022.” *World Shipping*, 2023, p.26.

[15] ReCAAP. “Incident Alert Sea Robbery Incidents in the Singapore Strait,” accessed at July 13, 2023.

which Resolution 1816 authorizes the relevant states, with the consent of the Somali Government, to enter the territorial waters of Somalia to use "all necessary means" "for the purpose of repressing acts of piracy and armed robbery at sea".[16] This has led to a rapid decrease of piracy attacks in the Gulf of Aden and other traditional regions with high risk of piracy incidents. In contrast, there was a sharp increase of the number of piracy attacks in the South-East Asian waters.

3. Factors for the high incidence of piracy in South-East Asia

The interweaving of many factors has led to the foresaid change of piracy incidents in the Southeast Asian Waters. These factors include: the special geographic structure of the Southeast Asian Waters, the "blank" legal provisions in the laws of the coastal countries along the passage, easy access to the equipment for piracy, the geopolitical conflict resulting from the Russian-Ukrainian conflict, and the de-globalization trend brought about by the industrial decoupling in some regions. These factors have not only exerted huge influence on the global supply chain, but also delayed the future development of shipping market. Shipping companies have to reduce their crew. Employment pressure have thus doubled, and social conflicts further concentrated. Shipping companies begin to decrease their investment in monitoring and combating potential pirates or armed robbers. Thus, a vicious circle is gradually formed to a certain extent. To summarize, piracy, maritime terrorism and other non-traditional maritime security issues are rooted in the interaction of economic, social, cultural, religious and other factors.

3.1 Geographical factors and legal gaps or loopholes

In terms of geopolitical structure, the Southeast Asian region is full of broken land and numerous islands. This structure is an excellent hiding place for pirates, and has become an objective condition for pirates to commit acts of piracy. In this region, piracy occurs not only in internal waters, territorial waters and the high seas adjacent to them, but also in the waters of a country or region and the adjacent waters of neighboring countries or regions. In fact, the major attacks on ships in navigation in the waters of Southeast Asia occur in

[16] “Resolution 1816 (2008) ,” adopted on June 2, 2008. file:///C:/Users/ Administrator/ Downloads/S_RES_1816(2008)-EN.pdf

the maritime areas over which a state has jurisdiction and do not fall within the scope of punishment under the Convention. For example, the Strait of Malacca is only 5.4 kilometers in width at its narrowest point. Thus, those attacks on ships in the Strait of Malacca do not meet the criteria for the crime of piracy according to the provisions of the domestic laws of some littoral states. And this or that similar situation has become a huge legal gap or loophole. In practice, many offenders take advantage of this legal gap or loopholes in terms of jurisdiction over the crime of piracy to avoid being punished by the laws.

3.2 Sustained growth in piracy capacity

In the process of globalization and development, contemporary pirates have also undergone some new changes, due to which they are very different from traditional pirates. Thus, the international anti-piracy mechanism has to be adjusted and optimized in tandem in order to jointly tackle the challenges of maritime security. The pirates in the Southeast Asian Waters are equipped with speedboats, global positioning systems (GPS), satellite phones, sub-machine gun and other advanced equipment, as well as cross-regional communication networks. Due to their "capacity growth" in this regard, the pirates can commit crimes in a higher rate of success, and even have armed capability to plunder large merchant ships. Of the 38 incidents of piracy occurred in the Singapore Strait in 2022, all ships were sailing in the waters, but were successfully boarded by pirates to commit their crimes.[17]

3.3 Complex political and social situation

The complex political and social situation in South-East Asia is also a factor that cannot be ignored. Shortly after the outbreak of covid-19, it was not suitable to use fishery products as the main source of food supply in an emergency situation, and the global fishery economy was nearly discontinued or closed. In order to prevent the COVID-19 pandemic, the industry chain of fishery economy was nearly broken. Under the influence of multiple factors, such as the lack of development opportunities and the shortage of governance capacity, the fishermen have seen a sharp rise of poverty

[17] Yuchi Cao, Guoping Zheng. “An Analysis of the Global Piracy Incidents in 2022.” *World Shipping*, 2023, p.28.

and unemployment rate. Thus, they have no choice but to do part-time piracy as a way to increase their incomes. Therefore, anti-piracy in Southeast Asia has long been a treatment of symptoms other than root causes. That is to say, it is difficult to completely eliminate piracy because it is difficult to eliminate poverty. In addition, pirates seek political purpose beyond their motive of economic gain.

3.4 "Terrorization" of piracy

Since the September 11 attacks in 2001, the fight against terrorism has reached an unprecedented level of intensity worldwide. Due to the strong counter-terrorism situation, terrorist organizations have shifted their targets to the maritime domain, which is vast in area and relatively weak in defensive forces. Although terrorism is different from piracy, they are not "clear-cut": they overlap in terms of perpetrators, criminal techniques, criminal networks and other nature.[18] A comparison between the pirates and terrorists in the Southeast Asian waters shows that the pirates lack organization and planning in general, whereas the terrorists, especially those terrorists in the Southeast Asian Waters, have a powerful force, a rigid structure, and an orderly division of work. In the process of committing crimes, pirates integrate themselves with terrorists. Some pirates also become members of maritime terrorism, and participate in related maritime terrorist activities, increasingly showing a trend towards piracy "terrorism".[19] Like the "syndicate", a form of monopoly organization in economics, piracy has become a "one-stop" industry by its use of a vast underground network of piracy, including robbery and stolen goods disposition.[20]

4. Regional anti-piracy mechanisms and China's acts

At present, the measures taken by the global community against piracy are mainly embodied in the international legal framework and the practice of international cooperation. Among them, the international legal framework is discussed in the previous text, the

[18] Murphy, Martin N. “Small Boats, *Weak States, Dirty Money: Piracy and Maritime Terrorism in the Modern World*.” York: Columbia University Press, 2009, p. 177.

[19] Ming Hu, Ying Xu. “Terrorization of Piracy: Three Models and Dual Regulation. ” *Social Science in Chinese Higher Education Institutions*. 2016, p.90, 94.

[20] Dong Yu. “Pirates Are Moving to Southeast Asia: the South China Sea Has Quietly Become a New Playground for the World's Pirates.” May 22, 2016, http://static.nfapp.southcn.com/content/201605/22/c84711.html

international cooperation practices include anti-piracy mechanisms established by professional organizations, regional cooperation institutions, etc. These professional organizations mainly rely on the IMO, IMB and other institutions. They provide important technical support for the international anti-piracy activities by developing anti-piracy technology, formulating international regulations, issuing piracy warnings, and establishing channels for information exchange and contact. Regional cooperation institutions include the long-term patrolling mechanism developed by the littoral states in the SOMS, and the ReCAAP intergovernmental anti-piracy mechanism established at the initiative of Japan. In addition, commercial organizations such as private maritime security companies complement the combat against piracy and armed robbery against ships. However, their roles are limited in comparison with that of the states, which remains the most important actor in the fight against the crime of piracy.

4.1 Regional anti-piracy mechanisms: processes and limitations

Both counter-piracy and counter-terrorism represent non-traditional security cooperation, particularly in less sensitive areas However, after a long time, the states in Southeast Asia have not really established a specialized ASEAN-centered anti-piracy cooperation mechanism. Under the intervention of extra-regional states and groups of states, especially the U.S., the Southeast Asian waters have become a key area for a new great power game. In addition, there are unresolved disputes over maritime rights and territorial sovereignty in the South China Sea. Thus, the Southeast Asian countries have not yet reached a consensus on the issue of combating piracy. Naturally, the cooperation among the littoral states of the SOMS continues to be dominated by functional matters. Therefore, though Malaysia, Singapore, Indonesia and even the ASEAN have made maritime security an important issue in their security policies, overall cooperation in this regard remains limited.

In 1992, Singapore, Malaysia and Indonesia signed the Agreement on Joint Prevention of and Countermeasures against Piracy. According to the Agreement, they began to launch joint operations to combat piracy, and began patrolling within their own territorial waters in the Strait of Malacca. In 2004, the U.S. Bush Administration proposed the Regional Maritime Security Initiative (RMSI). This Initiative was designed to combat piracy and potential

maritime terrorism in the Strait of Malacca by virtue of strong naval power. To that end, it envisioned that the U.S. and the Southeast Asian countries could share intelligence, standardize command structures, and establish maritime surveillance and interdiction capabilities. Singapore showed its support for the Initiative. However, it was eventually shelved by Indonesia and Malaysia, who feared that the Initiative would affect their national sovereignty. After that, the three ASEAN countries proposed and initiated the Malacca Straits Coordinated Patrol (MALSINDO). In 2005, Thailand became an observer state of MALSINDO, and established "Eyes in the Sky" (EiS), an air patrol mechanism, with Singapore, Malaysia and Indonesia. In 2006, the foresaid four countries further integrated MALSINDO, EiS, and another intelligence exchange mechanism into the Malacca Straits Patrol (MSP) mechanism. In October 2017, the Philippines, Malaysia, and Indonesia announced the launch of a joint air patrol to combat the threat of transnational crime, terrorism, piracy and other crimes in the Sulu Strait waters.

At the ASEAN level, a counter-piracy platform was established. It includes the ASEAN Regional Forum (ARF), ASEAN Defense Ministers' Meeting-Plus (ADMM-Plus), the ASEAN Maritime Forum (AMF) and the Expanded ASEAN Maritime Forum (EAMF) and other mechanisms. These mechanisms are designed to discuss cooperation through multilateral fora. They also organize a series of joint anti-piracy exercises, seminars, and training courses. In addition, they established anti-piracy information-sharing mechanisms with relevant states. In 1998, piracy was formally listed by ASEAN as a transnational crime. In 2003, the ARF issued a special Statement on Cooperation against Piracy and other Threats to Maritime Security. In 2008, ASEAN established the Counter-Piracy Task Force (CPTF).[21] Particularly in 2010, the AMF was created as an important initiative of the ASEAN Political-Security Community (APSC) Blueprint. This Forum was designed to be a new platform for maritime security cooperation among the ASEAN countries. In October 2011, Japan proposed an expansion of the ASEAN Maritime Security Forum (AMSF), and its first expanded meeting was held in the Philippines. Until August 2023, 13 AMF and 11 EAMF have been successfully organized. The institutionalization of the ASEAN Maritime Forum and Expanded Meeting shows an improvement and intensification of the

[21] Houguang Wang, Yuan Wang. “Ocean governance in ASEAN and Southeast Asia.” *International Forum*, 2017, p.16.

maritime security cooperation system in the Southeast Asian region. This will be conducive to safeguarding the security of the Southeast Asian waters, improving the maritime operational capabilities of the ASEAN countries, and enhancing ASEAN's overall regional governance capacity. However, there is still a gap between it and the goals for the creation of the system, especially the ultimate goal of establishing an ASEAN Political-Security Community (APSC).[22]

4.2 China's philosophy of anti-piracy and its state practice

To maintain maritime security is of great significance to the boost of prosperity, peace, stability and development in the world. As the world's most important shipping hub, the Asia-Pacific region contributes more than half of the world's economic activity. Thus, it is crucial to the development of the maritime transportation industry of the world. Non-traditional security issues, including piracy, have transnational and public feature and spillover effect. They cannot be properly resolved by any single state on its own. The waters of South-East Asia are full of danger for its extremely fierce and rampant piracy and armed robbery against ships. Therefore, relevant states and non-state organizations must uphold the idea of community with a shared future for mankind, actively participate in and cooperate with others in a long period in order to achieve successful fight against piracy and armed robbery against ships.

As a responsible power in the region, China attaches great importance to maritime security. Thus, China has consistently advocated the concept of common maritime security featured by mutual benefit, cooperation and is committed to creating a maritime security pattern based on mutual trust, equality, justice, fairness, joint contribution and shared benefits.[23] Maritime security cooperation should focus on combating piracy. China actively supports the global community in continuing to carry out escort operations against piracy in the relevant waters according to the relevant resolutions adopted by the Security Council. On December 20, 2008, the Chinese Navy began its first convoy to escort ships in the Somali waters of the Gulf of Aden. Over the past 15 years, China has dispatched a total of 44

[22] Yuyuan Zhou. “The Internationalization of Maritime Security Cooperation in Southeast Asia: The Role of the ASEAN Maritime Forum.” *Foreign Affairs Review*, 2014, p.140, 141,152.

[23] “Chinese Delegate Elaborates its Position on Maritime Security,” August 10, 2021.

batches of convoys to carry out escort missions, involving a total of more than 100 ships, with a completion of more than 7,000 escort missions for Chinese and other countries' ships. The Chinese convoys rescued and escorted nearly 100 ships of various types, of which more than 50% were ships registered in other countries and regions other than China. In this way, China has accumulated rich experience in combating piracy. [24]

About 90% to 95% of China's foreign trade was completed by maritime transportation. Thus, China attaches great importance to the potential threat posed by piracy to the world economy and regional stability, and also stresses maritime security cooperation with the Southeast Asian states that focuses on combating piracy. In his speech at the Special Summit to commemorate the 30th Anniversary of China-ASEAN Dialogue Relations, Chinese President Xi Jinping pointed out that the countries in the region confront various types of traditional and non-traditional security risks and challenges, and he concluded that they should adhere to pursue common, comprehensive, cooperative and sustainable security.[25] China began its cooperation with ASEAN in the 1990s, and has made breakthroughs due to the promotion of bilateral relations. In 2002, China and the ASEAN countries signed the Declaration on the Conduct of Parties in the South China Sea (DOC), establishing the common norms and basic principles for all parties to deal with the South China Sea issue. Specifically speaking, the DOC stipulates five major areas, including, but not limited to marine scientific research, marine environmental protection, maritime search and rescue, safety of maritime navigation and transportation, and transnational crime combating, for cooperation.

In addition, China is an active participant and builder of the Malacca Straits cooperation mechanism. China also actively participates in the anti-piracy operation and the "single track" and "dual track" mechanism related to maritime security in the Southeast Asian region. The operations and mechanisms include ADMM-Plus, ReCAAP, the Conference on Interaction and Confidence-Building Measures in Asia, China-ASEAN Maritime Consultation, Shangri-La

[24] "Chinese Navy: Successful Completion of 1568th Escort Mission by its 44th batch of Escort Convoy," June 8, 2023.

[25] "Speech by Chinese President Xi Jinping at the Special Summit to Commemorate the 30th Anniversary of China-ASEAN Dialogue Relations, " November 22, 2021

Dialogue, the Council for Security Cooperation in the Asia Pacific (CSCAP), Seminar on Non-traditional Security Cooperation in the South China Sea, Maritime Security Working Group, Container Security Initiative (CSI), etc.[26] In January 2004, China and the ASEAN countries signed the Memorandum of Understanding on Cooperation in the Field of Non-Traditional Security Issues. In the Memorandum, there is an initiative of establishing a maritime institutional consultation mechanism between China and ASEAN, which was put into practice in 2005. Up to the end of March 2021, the China-ASEAN Maritime Consultative Mechanism has successfully held thirteen meetings, continuing to strengthen the consensus on cooperation between the maritime agencies of China and the ASEAN countries. In 2011, the Chinese government initiated the setup of a RMB 3 billion China-ASEAN Maritime Cooperation Fund in order to form a multi-level and all-round maritime cooperation pattern between China and the ASEAN countries.[27]

5. Conclusion

The ocean is not only a treasure trove of resources on which mankind depends for its survival, but also a bridge for trade between nations. The shipping industry is the backbone of global trade and economy because seaborne trade accounts for 80% of global trade and more than 70% of its value.[28] At the same time, the shipping industry is facing the serious challenge of reducing emissions. According to the data released by the International Maritime Organization, the global shipping industry emits about 1 billion tons of greenhouse gases every year, accounting for about 3% of total global emissions.

The year 2023 is of great significance for China. It is the 10th anniversary of Chinese President Xi Jinping's initiative to build a closer China-ASEAN community with shared future and the Belt and Road Initiative(BRI). It is also the 50th anniversary of the restoration of China's lawful seat as a member of IMO. Undoubtedly, the Chinese

[26] Yuanzhe Ren, Hanqing Liu. “The Non-traditional Security Cooperation in the South China Sea Region and China's Role.” *Journal of Boundary and Ocean Studies*, 2017, pp.4-9.

[27] Jiabao Wen. “China Will Set up a RMB 3 Billion China-ASEAN Maritime Cooperation Fund,” November 18, 2011.

[28] “Asian Voice in the Global Shipping Industry: Shipping Industry's Top Conference Returns to Shanghai after 7 Years,” accessed at May 17, 2023.

government will continue to work with all countries in the region to implement the Global Security Initiative (GSI), conduct joint maritime exercises with the Southeast Asian countries for maintaining maritime security, and jointly respond to the threat of piracy. In addition, China will also deepen its practical cooperation in the fields of anti-piracy and maritime law enforcement, and make positive efforts to realize peace and tranquility on the oceans. In this way, China will follow a new type of security road that is characterized by dialogue other than antagonism, companionship other than alliance, and win-win other than zero-sum.

Meanwhile, the Chinese governments, enterprises and industries related to maritime should continue to take action. They should improve their working mechanism of ships for piracy prevention and emergency response, improve the early warning mechanism, strengthen international exchanges and cooperation, pay close attention to global piracy attacks, and have the knowledge of the dynamics of pirate attacks. They should also ensure that all preventive measures are predictive and targeted. More importantly, regional security awareness and risk awareness are increasing at present. Thus, there is a continuous call for global data sharing strengthening, and a breakthrough in the limitations on national geography and space. In addition, there should be an enhancement of their own digitalization capacity building in order to meet the data security requirements among different customers. In this way, they can promote the construction of maritime connectivity between China and the ASEAN countries, and enhance cooperation in the fields of shipping, maritime affairs and ports.

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Optimizing Port Efficiency: Unveiling Disparities and Potential of Port Community System (PCS) Deployment at Port Qasim for Economic Growth and Technological Transformation

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Abstract

The integration of technology has demonstrated its capacity to enhance organizational operations and foster economic development. Just as in various other sectors, the maritime industry also demands the digitalization of its operations through an efficient and seamless IT system – known as the Port Community System (PCS). The PCS serves as a secure technological platform that facilitates the exchange of data and information flow among the myriad of public and private entities involved in seaport operations. This research endeavors to explore the disparities between the existing and proposed procedures at Port Qasim, with a particular focus on the implementation of the PCS within the framework of Port Qasim Authority. Employing structural equation modeling via PLS-SEM, the study collected data through a Likert questionnaire featuring a 5-point scale. This questionnaire was administered to 123 respondents, all of whom were esteemed port professionals at Port Qasim. The findings unveiled that the perceived impact of the introduction of the PCS holds a positive and significant influence over overall process efficiency and workflow. Correspondingly, the pre-requisite knowledge required is found to have a positive and significant relationship on perceived impact of PCS introduction at the port. Nonetheless, the correlation between

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the prerequisite knowledge and process efficiency was deemed insignificant. This implies that possessing prior knowledge of PCS doesn't inherently translate to increased process efficiency. Interestingly, this gap can be bridged effectively through targeted training sessions, enabling users to harness the full potential of the PCS without adversely affecting process efficiency. Nevertheless, with streamlined data exchange and efficient information flow, the PCS can reduce port congestion, enhancing trade operations and positioning Karachi as a competitive trade hub. Economically, this translates into increased trade throughput, improved logistics, and heightened business attractiveness.

1.1 Introduction

Seaports are essential for promoting global trade and economic expansion in a world that is becoming more interconnected and globalized. An intricate web of operations involving numerous stakeholders must be orchestrated for these crucial nodes of commerce to operate effectively. The marine industry is also employing digitization and altering traditional processes to transition towards a faster and more efficient flow of information, strengthening its network, like every other industry in the world that is using technology and various ICT and EDI applications. Moreover, Author[1] claimed that in a fast-paced and ever-changing ICT market, efficient chain wide integration and collaboration are vital to enable better supply chain performance. Hence, the flow of information regarding chain-wide activities among entities such as ships, hinterland transport networks and cargo stakeholders, is of utmost importance in ship-port relationships.[2] Moreover, ports around the world are now competing and utilizing technological advancement transforming in enhancing their port ecosystem. To ensure seamless collaboration among these stakeholders and streamline the flow of goods, the concept of a single window platform has emerged as a strategic solution. One of the tools that can be widely used for enhanced

[1] Zohaib, H. S., & Zaidi, S. S. (2022). Antecedents of maritime supply chain resilience affecting supply chain performance– an empirical study based on the pharmaceutical industry. GMJACS, 12(2), 81–101. https://doi.org/10.59263/gmjacs.12.02.2022.256

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integration, collaboration and comprehensive port management is the Port Community System (PCS).[3] The PCS allows connecting all the entities of the maritime chain via a unique platform utilized for sharing information. [4] Without a doubt, the ports that have adopted PCS have seen their operations become considerably smoother and more efficient, transforming them into world-class ports.

Port Community Systems have become a staple technological platform used to exchange information between the public and private agents and entities involved in ship and cargo services within seaports. [5] PCS benefits not only the port but all the entities that are using the port ranging from ship owners, ship agents, customs, and terminal operators, to even private companies i.e., connects B2B, B2C and B2G services. Additionally, port collaboration's physical, information and financial flows are interdependent, thus causing a lot of coordination challenges for entities involved in the port operation. To address these challenges, port collaboration is commonly supported by a Port Community System (PCS), which is the state of the art in information systems and connects SC actors in port environments using inter-organizational services.[6]

Besides, authors [7] claimed that seaports must continuously improve their commercial and administrative operations to stay competitive. Similarly, Pakistani seaports still have a long way to go in adopting new ICT systems and other sustainable technological advancements. Out of Pakistan's three (3) port Authorities, only

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[6] Chandra, D. R., & Hillegersberg, J. V. (2018). Governance of inter-organizational systems: a longitudinal case study of Rotterdam's Port Community System. International journal of information systems and project management, 6(2), 47-68.

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Karachi Port Trust (KPT) has put some effort to integrate itself with Electronic Data Interchange (EDI), However, Port Qasim & Gwadar Port Authority - have still a long way to go in this direction (USAID's Pakistan Regional Economic Integration Activity, (PREIA 2021). As observed externally, to date PQA is relying on the traditional/old school method of data collection, which not only is unreliable but is time taking and cuts down the efficiency of the port drastically. The port activities are being done in conventional ways with no automation and minimal digitalization. This reliance on conventional means of port operations may become a question of survival in future if the same practices are followed.

Additionally, Pakistan faces immense challenges in transforming its seaports and making use of modern systems for Port automation. There are three (3) port authorities and five (5) container terminals in Pakistan. The progress observed over the last twenty-five (25) years to date is only in terms of bringing Ship-to-Ship (STS) and Rubber-Tyred Gantry (RTG) cranes to container terminals. Just recently, work on Radio-Frequency Identification Devices (RFID), scanners, automated gates, and remote STS/RTG operations have begun but only on private entities and not on Government owned ports (USAID's Pakistan Regional Economic Integration Activity [PREIA], 2021).

Therefore, the research objective of this article is twofold. The first is to highlight the significance of PCS by understanding the role of PCS in facilitating efficient and secure information exchange and collaboration among various stakeholders in a port community at Port Qasim. Secondly, to examine the current state of information exchange and collaboration among the stakeholders and identify all the inefficiencies or bottlenecks, which can be resolved by deploying a Port Community System at Port Qasim. However, the deployment would reduce time and effort and make the operations smoother than ever resulting in increased port competitiveness and more ship calls. Thus, this paper identifies the bottlenecks and outlines the potential benefits of PCS adoption at the PQA.

1.2 Process Assessment

Port Operational processes are mapped by utilizing Business Process Modelling Notation (BPMN) 2.0 by Signavio. The scope of this study covers only 3 operational port processes as-is process

(current) and proposed to-be process (future) for the same. However, more may be realized and analyzed for future studies. Processes that have been discussed in this study include Vessel Registration, Ship clearance and nautical services - port dues. The paper also comparatively analyzes the as-is process with the to-be processes to realize the gap between the current and the proposed methods.

1.2.1 Vessel Registration: (Current Process)

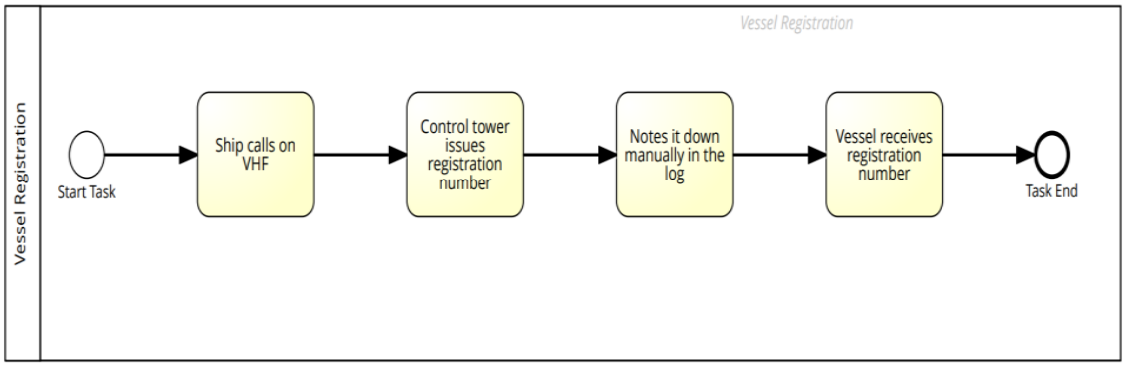

Figure 1- *Current Vessel Registration Process*

The current process of Vessel Registration is a series of processes (Figure 1), which is being followed despite having multiple handing over and taking over. A sequential process could create various bottlenecks such as vessel registration cannot be completed until the control tower issues a registration number and then archive it manually. The process is initiated by the vessel calling on VHF and establishing contact with the port's control tower, which then issues the vessel a manually generated registration number and records it in the port's logbook. After receiving the registration number, the vessel then must wait for its turn at the anchorage to berth as per the allotted registration number. The process of vessel registration is quite simple, yet it has some drawbacks due to the non-digitalized approach. The delays and distortions in the VHF connectivity, manually written registration numbers (which could lead to undesired errors or confusion) and, manual record keeping instead of database management and cloud computing etc, may halt the process or make it inefficient.

1.2.2 Vessel Registration on PCS: (Proposed Process)

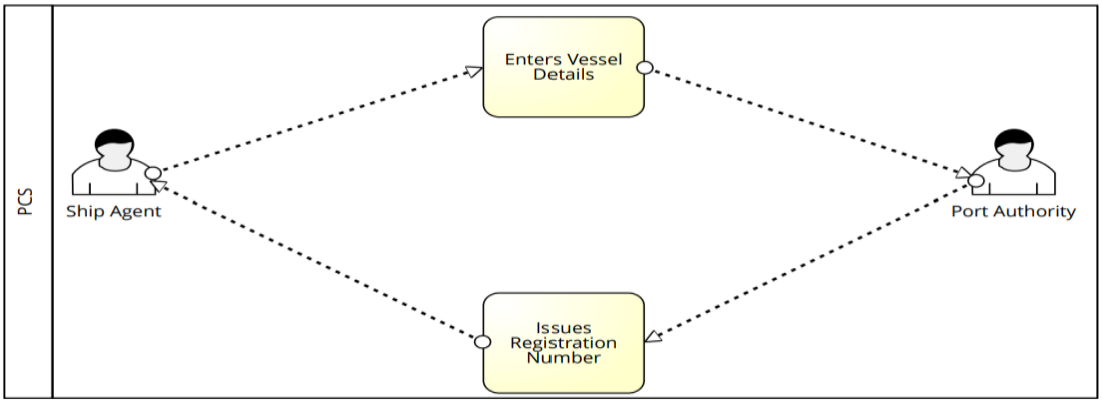

Figure 2- *Proposed Vessel registration Process deployed via PCS - mapped on BPMN 2.0*

As compared to the current vessel registration deployed process, the proposed process (Fig 2) eliminates various bottlenecks and presents a digitalized/automated registration process. Although, a ship agent or ship master must enter vessel details on the portal which is then verified by the port authority and an automatically generated registration is provided to the vessel. This simplified process reduces the lead time of the vessel registration process and may record it in its PCS database for future usage.

1.2.3 Ship Clearance (Current Process)

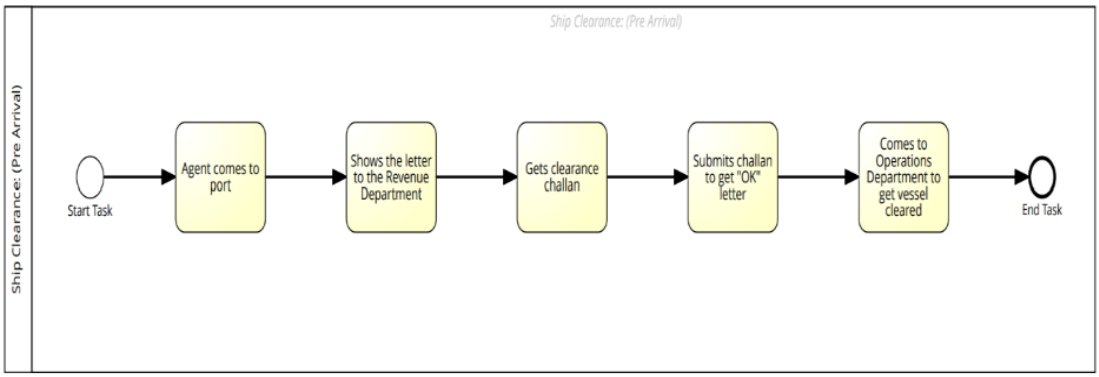

Figure 3- *Ship clearance current process*

Again, being a sequential process, ship clearance involves multiple port departments and personnel. Due to various entity involvements, a process becomes more delicate and becomes more prone to disruption by a small hindrance at any of the echelons

triggering a domino effect in the entire procedure. In the case of conventional Ship Clearance process, the shipping agent is required to visit the port to present the letter to the revenue department to receive a clearance voucher. This voucher is paid by the custom clearing agent to the respective banking facility which is then transmitted to concerned department for further issuance of clearance letter (the clearance letter indicates that the vessel is cleared of all pending dues and is allowed to be berthed at the port). The clearance letter is then submitted to the Marine Operations Department to get the vessel cleared.

1.2.4 Ship Clearance (Proposed Process)

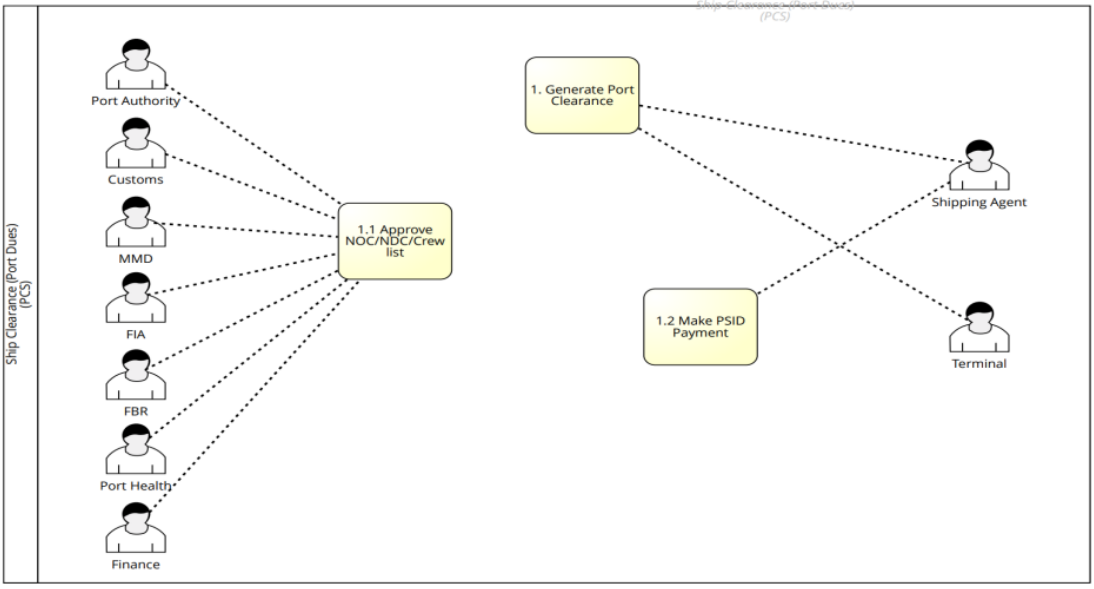

Figure 4- *Proposed ship clearance process deployed via PCS-mapped on BPMN 2.0*

The proposed method (Fig:4) of PCS makes ship clearance much easier as all the concerned departments including the port authority, customs, mercantile marine department (MMD), FIA, FBR, and Finance departments approve the NOC/NDC/Crew list simultaneously in real-time on a platform and can easily be accessed remotely.

1.2.5 Nautical Services (Current Process)

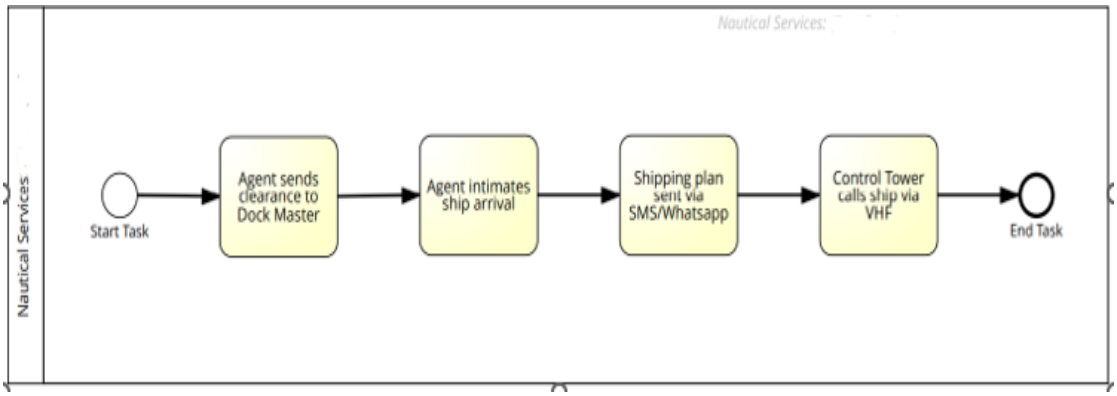

Figure 5- *Nautical Services (Current Process)*

To avail the nautical services at the port after clearing port dues, the agent sends a clearance letter to the Dock Master with the prior intimation of ETA (estimated time of arrival). Dock Master then designs a daily/weekly shipping schedule accordingly and circulates it via SMS, WhatsApp, or any other 3rd party communication application. The ship then waits for its turn to be called by the control tower via VHF for further maneuvering in the navigation channel for birthing.

1.2.6 Nautical Services (Proposed Process)

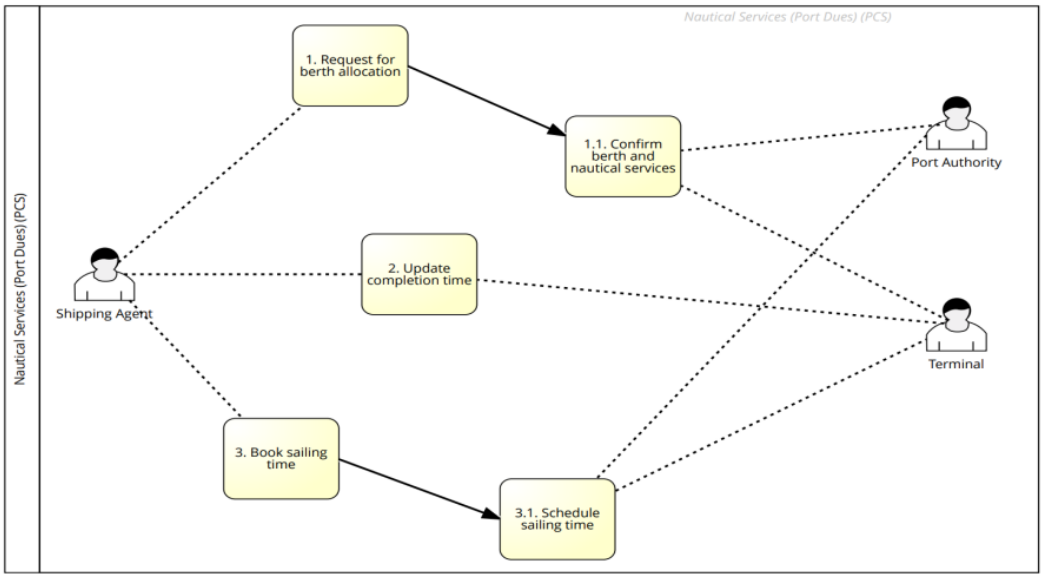

Figure 6- *Nautical services process deployed via PCS-mapped on BPMN 2.0*

Whereas the same process done through a PCS is fast and efficient, on the other hand, it simultaneously eliminates various

entities and makes it more simplified. Ship agent requests for berth allocation through the portal and the port authority confirms it by cross-checking all the vouchers (dues) in a digitalized manner. After verification, the port authority accepts the request and inculcates it in the shipping plan and allows the ship for further navigation. In all this process the relevant terminal operator and ship agents are all kept in the loop as shown in Figure 6 to get real-time information on the shipping plan for further smooth functioning of the operation.

1.2.7 Process Assessment Summarized

From the above illustrated, it is evident that significant resource saving may be achieved by the adaption of PCS as the process lead time is probable to get lower compared to that of the conventional process performed on legacy systems. Additionally, PCS simplifies the existing administrative procedures but also eliminates various bottlenecks from the port processes, by filtering out redundancies and connecting the relevant person to the concerned entity/department only.

The introduction of PCS is a step towards paperless and more efficient seaports, author[8] reported that not only it comes with the commercial benefit of lowered costs, but a greener approach. The implementation improves the flow of information among various entities, reduces communication delays and increases trade security. Furthermore, the deployment of the PCS within the port premises allows more volumes/TEUs to be catered within a specific period which leads towards the enhancement of the port competitiveness[9], resulting in a better corporate image. The use of such platforms has a huge economic/commercial impact, as they help increase the productivity and efficiency of the port.

Moreover, in contrast to the current processes, the proposed processes are not series which actuate various operations simultaneously rather becoming a bottleneck for the proceeding tasks. Thus, making the process faster, more efficient, and smoother. As

[8] El-Miligy, B. (2013). Enhancing the efficiency of the supply chain documentation flow through the application of an e-business model: a case study of Alexandria Port (Doctoral dissertation, University of Huddersfield).

[9] Abdallah, R., Besancenot, J., Bertelle, C., Duvallet, C., & Gilletta, F. (2023). An Extensive Preliminary Blockchain Survey from a Maritime Perspective. Smart Cities, 6(2), 846-877.

authors [10] claimed that EDI tools and applications provide a faster and more efficient exchange of information, lower the overall operational cost, reduce lead time, and improve data sharing among departments and significantly decreases human errors.

2.1 Hypothesis Development

2.1.1 Perceived Impact of Introduction of PCS and Process Efficiency

By introducing the concept of a Port community system within a port, the diverse parties/stakeholders such as port authorities, carriers, and freight forwarders may be brought to one platform for fulfilling the need for standardization, which results in the smooth and transparent flow of information. [11] This eventually results in the improved efficiency of work and output of the port. Furthermore, author [12] stated that Port Community System is a single platform that can be introduced for the purpose of comprehensive port management. Hence it implies the fact that for the purpose of improving the process efficiency at the port; the introduction of PCS plays an essential role in it. Therefore, it may be hypothesized as:

H1: Perceived impact of introduction of PCS has significant impact on process efficiency.

2.1.2 The Prerequisite Knowledge Required to operationalize PCS and Process Efficiency

Having prerequisite knowledge about a subject can be advantageous for the better understanding and implementation of it however it doesn't imply the fact that desired results cannot be achieved without having the prerequisite knowledge. Keceli stated that PCS has already been implemented in various ports in Europe,

[10] Obara, P. M., Kiplagat, L. J., & Okidi, A. N. (2010). The Benefits and Challenges of Electronic Data Interchange. Implementation and Application at Kilindini Water Front Project in Kenya. African Journal of Business & Managemen, 1, 212-236.

[11] Srour, F. J., van Oosterhout, M., van Baalen, P., & Zuidwijk, R. (2008). Port community system implementation: Lessons learned from international scan. In Transportation Research Board 87th Annual Meeting, Washington DC.

[12] Keceli, Y., Choi, H. R., Cha, Y. S., & Aydogdu, Y. V. (2008, November). A study on adoption of port community systems according to organization size. In *2008 Third International Conference on Convergence and Hybrid Information Technology* (Vol. 1, pp. 493-501).

where they have been operated as tailor-made solutions to the ports' complicated processes. This may allow other ports to gain sufficient knowledge to successfully deploy PCS at their ports. However, if individuals, organizations, port authorities and other stakeholders linked to the port community systems possess the required level of understanding and skillset to effectively utilize and leverage the capabilities of the PCS, the port operations are more probable to experience positive outcomes. Hence, it may be posited that:

H2: Prerequisite knowledge required to operationalize PCS has a satisfactory impact on the overall process efficiency.

2.1.3 Prerequisite Knowledge Required and the Perceived Impact of Introduction of PCS

In recent years, maritime supply chain and port management have evolved tremendously, backed by the rapid growth and integration of information and communication technologies. Port Community System all over the world are linked with and come under the umbrella of ICTs. authors[13] claims that the evolution and understanding of ICTs has encouraged a more integrated port community. Furthermore, PCS often require integration with existing systems and the ability to interact with various digital platforms used by various stakeholders. These integration protocols and interoperability require sufficient pre-requisite knowledge for deployment as well as for smooth deployment of the PCS at the port. Therefore, it may be hypothesized as:

[13] Caldeirinha, V., Felício, J. A., Salvador, A. S., Nabais, J., & Pinho, T. (2020). The impact of port community systems (PCS) characteristics on performance. Research in Transportation Economics, 80, 100818.

H3: The prerequisite knowledge required has a positive impact on the introduction of PCS.

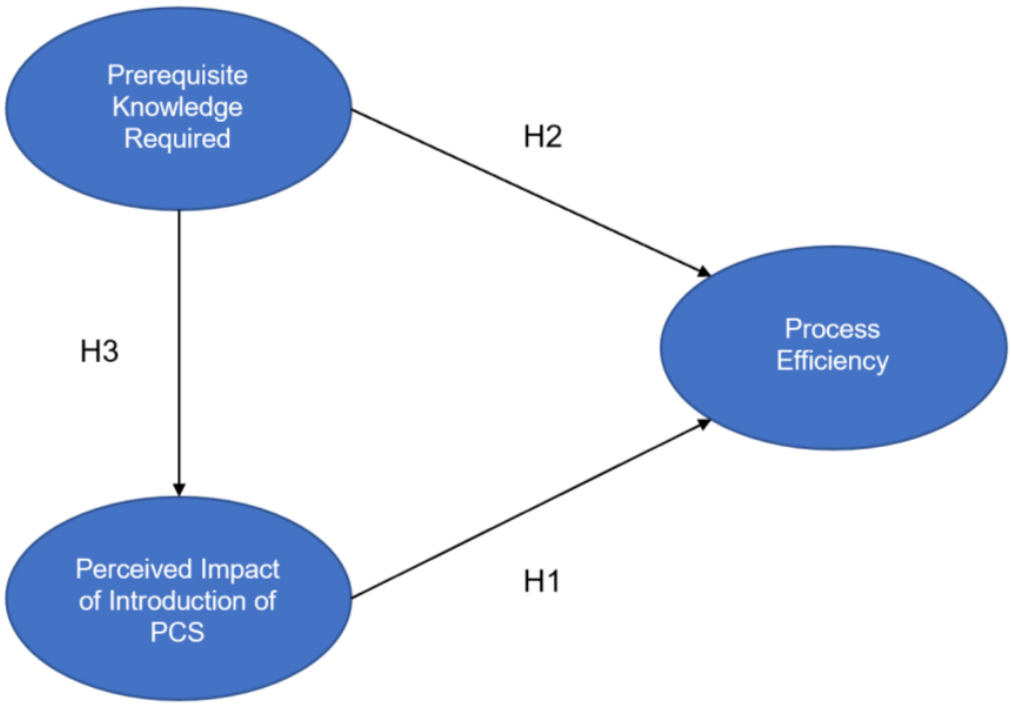

Figure 7- *Conceptual framework depicting the relationship of prerequisite knowledge required, perceived impact of introducing PCS at the port and port process efficiency.*

3. Research Methodology

The purpose of this study is to highlight the importance of the Port Community System (PCS) to strengthen information exchange and collaboration among stakeholders at Port Qasim, and it also seeks to identify gaps that can be resolved through PCS deployment. The gap is realized via process analysis performed on Business Process Modeling and Notation (BPMN 2.0) by Signavio. The current and proposed processes are presented for gap realization.

Furthermore, for correlational based research, data gathering and analysis, a quantitative method is used. An online based Likert-scale questionnaire survey is used to collect data. The

questionnaire is intended to analyze stakeholder responses regarding PCS implementation and potential benefits. The Daniel Sooper calculator is used to establish the sample size of 123 respondents, ensuring enough representation from relevant departments at Port Qasim Authority. The data collected for this study is primarily quantitative, and the analytical approaches used include Partial Least Squares Structural Equation Modelling (PLS-SEM) with Smart PLS software. Moreover, the statistical software SPSS is used to do reliability analysis. These software tool options are well-suited to the study's specific requirements and properly align with its aims.

4.0 Data Analysis

4.1 Demographic Analysis

It is evident from the demographic analysis of the respondents that the majority of the research participants were postgraduates (68.8%), whereas the remaining few of them (31.3%) were graduates. Additionally, 43.8% of the respondents belonged to the age group of 41-50 years, 40.6% were from the age bracket of 31-40 years, and 12.5% were from 51-60 years. Lastly, 28.1% of the respondents were found to have professional experience of more than 20 years, 9.4% had 16-20 years of experience, 34.4% had an experience of 11-15 years, and 28.1% of the respondents had less than 10 years of experience.

Table 1: Respondents' demographic profile

		Count (123)	Table N % (100%)
Age	21-30	0	0
	31-40	50	40.6%
	41-50	54	43.8%
	51-60	19	15.6%
Qualification	Graduate	38	31.3%
	Postgraduate	85	68.8%
	Doctorate	0	0
Professional Experience	1 to 5 Years	15	12.5%
	6 to 10 Years	19	15.6%
	11-15 Years	43	34.4%
	16-20 Years	12	9.4%
	Above 20 years	34	28.1%

4.2 Pilot Testing

Before running a full-scale analysis, pilot testing was performed on 16 responses using IBM SPSS 24.0. The results motivated to perform further analysis because the values calculated met the required benchmark and the attained values lied between 0.7-0.9.

Table 2: Reliability Analysis

Variables	No. of Items	Cronbach`s Alpha
Prerequisite Knowledge Required	4	0.725
Perceived Impact of PCS Introduction	4	0.729
Efficiency	4	0.849

Table 3: Cronbach's Alpha value of all the variables collectively

Cronbach`s Alpha	No. of Items
0.901	12

4.3 The Measurement/ Outer Model

4.3.1 Factor Loadings

The association between the variable and its accompanying indicators is determined by factor loadings or outer loadings. The factor loadings should have a minimum value of 0.70. The values of outer loadings for all items in this study are larger than 0.7, indicating a correlation between the indicators and the constructs.

Table 4: Factor loading

	PE	PIIP	PKR
PE1	0.806		
PE2	0.862		
PE3	0.803		
PE4	0.834		
PIIP3		0.794	
PIIP4		0.823	
PIIP5		0.852	
PKR1			0.754
PKR2			0.713
PKR3			0.787
PKR4			0.699

4.3.2 Internal Consistency Reliability

It measures the relationship between the indicators of similar constructs. Authors [14]stated that composite reliability (rhoc) is one of the primary measures to evaluate internal consistency, whose value must exceed the minimum threshold of 0.70. Moreover, Cronbach's alpha is used as an alternative measure, which follows the same threshold as that of composite reliability. [15] Table 4.4 shows the values of both the measures of internal consistency reliability, and it is evident that the model meets the required benchmark of indicators' reliability.

[14] Bagozzi, Richard P., and Youjae Yi. "Specification, evaluation, and interpretation of structural equation models." Journal of the academy of marketing science 40 (2012): 8-34.

[15] Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2021). A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications.

Table 5: Internal Consistency Reliability

Variables	Cronbach Alpha	Composite Reliability
Perceived Impact of PCS Introduction	0.765	0.863
Pre-req Knowledge Required	0.725	0.828
Process Efficiency	0.849	0.882

4.3.3 Convergent & Discriminant Validity

There were two types of validities assessed: convergent and discriminant validity. Convergent validity discusses the convergence of the construct that indicates the variance of the indicators. It is quantified using the AVE value (Average Variance Extracted), which must be at least equal to or greater than 0.5 indicating that the construct explains 50% of the indicators' variance (Hair et al., 2021). Table 4.5 shows the AVE values, indicating that the proposed model meets the prerequisite and has acceptable convergent validity.

Table 6: Convergent Validity evaluated via Average Variance Extracted

Constructs	Average variance extracted (AVE)
Perceived Impact of Introduction of PCS	0.678
Pre-req Knowledge Required	0.546
Process Efficiency	0.683

Discriminant validity shows the measures of construct that theoretically should not be highly corelated to each other. To assess discriminant validity of the structural model, Fornell and Larcker's criteria and the Heterotrait-Monotrait (HTMT) ratio are evaluated. The Fornell and Larcker criterion employs that the values of the AVE square roots of variables should be greater in comparable pairings than in different ones.[16] Furthermore, HTMT criteria require the values

[16] Chin, Wynne W. "The partial least squares approach to structural equation modeling." Modern methods for business research 295, no. 2 (1998): 295-336.

of distinct pairs to be less than 0.85.[17] Tables 7 and 8 present the findings for the current model, which show that both requirements are met adequately, manifesting the existence of discriminant validity.

Table 7: Discriminant Validity (Fornell-Lacker Criterion of Constructs) *

	PIIP	PKR	PE
PIIP	0.824		
PKR	0.380	0.739	
PE	0.405	0.226	0.826

Table 8: Discriminant Validity (Heterotrait–Monotrait (HTMT) Ratio) *

	PIIP	PKR	PE
PIIP			
PKR	0.496		
PE	0.472	0.278	

***Note:** PIIP**=**Perceived Impact of PCS Introduction, PKR= Pre-req Knowledge Required, & PE=Process Efficiency.

4.4 The Structural or Inner Model and Path Analysis

The path analysis results show the relationship between the factors that influence one another at a given level of significance. This significance level is chosen at 5% in the current study, and the analysis is performed with bootstrapping iterations of 5000. The Table 9 exhibits the relationship between the independent and dependent variable where PIIP on PE ($p<0.05$, $\beta=0.373$) and PKR on PIIP is found to positive and significant ($p<0.05$, $\beta=0.380$) whereas the impact of PKR on PE is positive but found to have insignificantly linked up with each other ($p>0.05$, $\beta=0.085$).

[17] Henseler, Jörg, Christian M. Ringle et Marko Sarstedt. « A new criterion for assessing discriminant validity in variance-based structural equation modeling ». Journal of the Academy of Marketing Science 43, no 1 (2014), 115-35. doi:10.1007/s11747-014-0403-8.

Table-9: Hypotheses Testing*

Path	Coefficient	P-Values	Result
PIIP → PE	0.373	0.000	Supported
PKR → PE	0.085	0.418	Not Supported
PKR → PIIE	0.380	0.000	Supported

***Note:** PIIP=Perceived Impact of PCS Introduction, PKR= Pre-req Knowledge Required, & PE=Process Efficiency

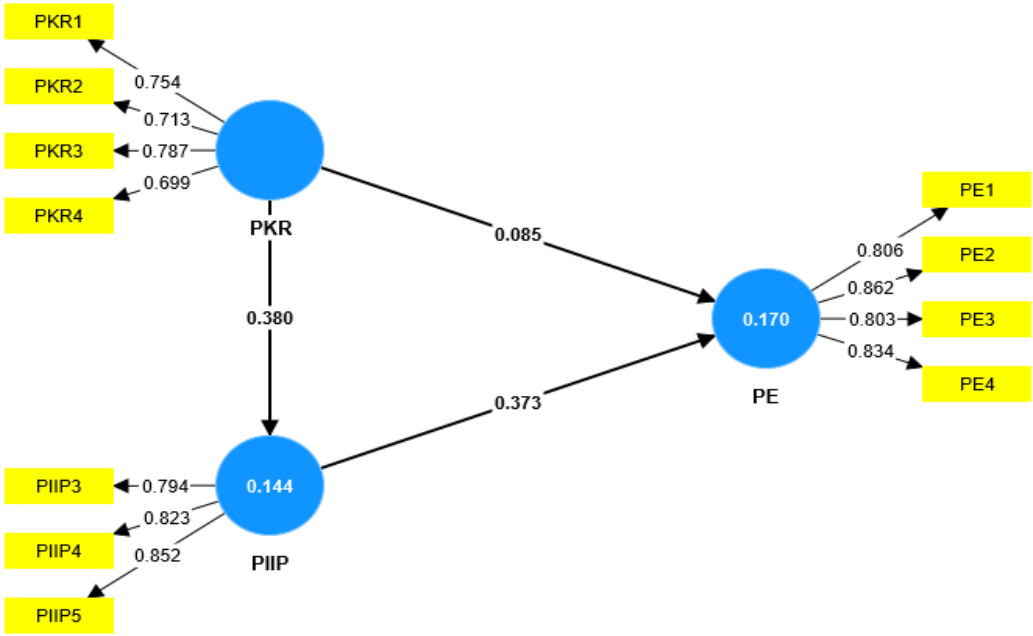

Figure 3: *PLS-SEM model after bootstrapping*

5.1 Conclusion

The maritime sector is heavily relying on ICTs and digitalization due to which improvisation at offshore as well as onshore sides is a compulsion. To remain competitive in the entire port cluster, ports are utilizing technological advancement to attract more TEUs and thus more shipping lines. This study emphasizes the significance of PCS deployment at PQA for the optimized operability of the port and its terminals. With improved processes, the PQA will experience smarter and more efficient port operations resulting in more market share and thus profitability.

The results of the study demonstrate that the success probability of PCS implementation at PQA is considerably high. As the

respondents were quite sure about the fact that the introduction of the PCS at PQA would lead to efficient and transparent port operations. However, it was notified that a sufficient level of IT knowledge and skills are required for the successful implementation, operationalization and thus utilization of the PCS at the port. However, the PKR is insignificantly related to PE as the usability of the PCS can be acquired via training session and would not affect the process efficiency at all as the process has already been mapped during implementation phase. Furthermore, the study also includes revamping of 03 key processes: Vessel Registration, Ship Clearance & Nautical Services (port dues) which also accentuates that the entire value chain visibility would be enhanced making processes smarter, reducing delays, and promoting overall efficiency by eliminating the bottlenecks and redundancies. Moreover, the port may get value-added benefits from PCS as it also allows cargo tracking and tracing capabilities, enhanced vessel traffic management, improved chain wide logistical coordination, e-payment and invoicing methods.

In consideration of the current practices at PQA, the port is still using traditional methods that need to be transformed into a single window operation. The transformational changes would require ample time for its full-scale deployment, but they will bring tremendous benefit to the stakeholders of the port value chain. Nevertheless, the entire maritime industry is transforming and becoming more and more smarter i.e., the ships are getting smart which in turn demands the ports to modify the conventional port processes to technologically enabled port operations. The future demand for smart shipping will cause the PQA to lose the entire smart ship volume subjected to no advancement or innovation adoption by the port authority. The zero or minimal adoption will raise the question for survival of Port Qasim as this will induce operational inefficiencies, reduced transparency and ultimately hinder the port’s ability to fully capitalize on its trade potential. Therefore, the deployment of a Port Community System at Port Qasim, Karachi is crucial for the future growth and success of the port. By taking this initiative, the port can attract more shipping lines and create opportunities for increased business. It is essential to act swiftly to ensure that Port Qasim remains competitive and appealing to the shipping industry. With the implementation of a Port Community System, Port Qasim can streamline its operations, improve efficiency, and ultimately enhance its position as a key player in the region's maritime trade.

5.2 Recommendations

The paper has provided valuable insights into the potential benefit of the deployment of PCS at PQA. It is highly recommended to the PQA take considerable measures regarding the PCS deployment at the port. Based on the finding and the current status of the port operation, the following recommendation is put forth to guide the successful implementation of the PCS at PQA and to ensure its optimal impact on port processes.

- To better compete global market, the port suggested building the reliability of the PCS regardless of the cost incurred as the enhanced security and better networking compatibilities must be fully addressed for successful deployment and operability of the port. Moreover, privacy measures such as encryption implementations, access controls, and authentication protocols, must be taken into consideration to safeguard sensitive information.

- Comprehensive stakeholder engagement is recommended to connect all of the entities on a single platform including government agencies, terminal operators, shipping lines, freight forwarders, customs officials, and trucking companies. Therefore, a shared understanding of PCS objectives will be essential in securing their participation and commitment.

- A comprehensive need assessment and development of a user requirement document covering the entire end-to-end chain of the port logistics is suggested. Moreover, customized PCS deployment is also recommended in consideration of the unique characteristics and challenges of the PQA.

- Establishing a system for ongoing performance monitoring and continuous improvement of the PCS is recommended. Additionally, to identify areas for optimization and improvement via collecting regular feedback from port users and stakeholders.

- The module for continuous vessel monitoring solutions could be proposed to be integrated with PCS to monitor the daily vessel activities at the port and its premises.

- The PCS may be integrated with ERPs of the industries i.e., major stakeholders of the port, inter and intra port connectivity via EDI (Electronic Data Interchange) and cloud-based computing may be utilized for enhanced communication and collaboration between various ports in the cluster.

- PCS may be equipped with advanced analytics and reporting capabilities that enable port authorities to identify potential risks and take proactive measures to mitigate them. This can improve the overall safety and security of the port.

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Kaup, M., Deja, A., Ślączka, W., & Gróbarczyk, M. (2021). The port community system as an example of integration of port users. *Procedia Computer Science*, *192*, 4396-4405.

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Appendix-I

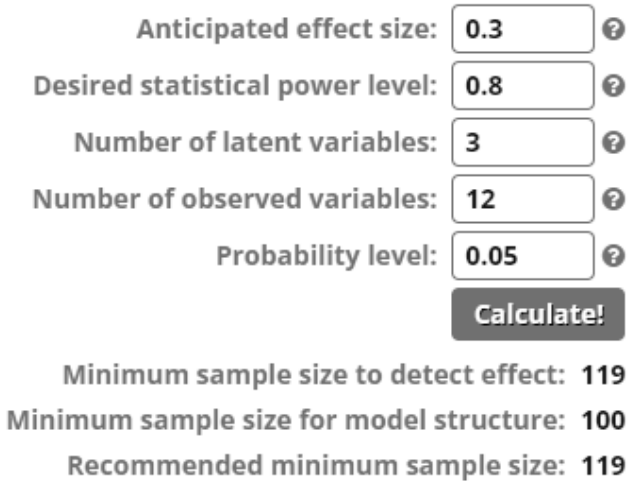
S.No	Perceived Impact of Introduction of PCS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	The introduction of PCS would make our work easier than before at Port Qasim.					
2	I believe that the use of the PCS would improve the integration between port users and the hinterland at Port Qasim.					

3	I believe that with the implementation of PCS there would be transparency in the system.					
4	The introduction of PCS would bring about the right/competent people for the right job.					
5	My knowledge of IT systems is in line with port activities					
6	I am well aware of the functionalities of the Port Community System.					
7	I have had a similar platform usage experience in the past.					
8	I possess the right/appropriate level of skill/qualification required to operationalize the PCS					

S.No	Perceived Impact of Introduction of PCS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
9	The use of PCS would accelerate access to data and information flow between integrated transport actors in the premises of Port Qasim?					
10	The PCS would enable the simplification of administrative procedures at Port Qasim?					
11	The use of the PCS would reduce cargo handling/turn around time at Port Qasim?					

12	The implementation of the PCS would considerably improve the competitiveness of port user companies and its stakeholders at Port Qasim?					

Appendix-II



Monitoring Emissions over Coastal Regions of Pakistan: Current Status and Applicable Techniques

Authors: Fasiha Safdar*, Saba Zeenat**, Bilal Abdul Nasir***

Abstract

Shipping operations have an environmental impact both in ports, as well as in the immediate vicinity of the coast. These impacts are due to the fuel burning exhaust from the ship's main and auxiliary engines which contain gases like Carbon Dioxide (CO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) and machinery used for loading and unloading, in addition to particulate matter and dust from the handling of materials such as grain, coal and sand.

Remote Sensing (RS) and Geographic Information System (GIS) is an efficient tool being used worldwide for the monitoring of environmental problems. Response of Earth's atmosphere or surface to electromagnetic radiation can be mapped through RS for the status of changes in the natural environment. Smart sensors developed for detection of air pollutants is an emerging technique to monitor emissions for real time monitoring and management of air pollution in distant regions.

In the current study, satellite data is used to investigated concentrations of key emissions from shipping operations at ports to analyse the status of air pollutants over coastal regions of Pakistan. The pollutants investigated in this study through RS and GIS technique include CO_2, SO_2, NO_2, CO and Particulate Matter (PM). These emission trends can be used to determine the efficacy of mitigatory measures to reduce emissions at ports and monitor the air quality of coastal areas. Furthermore, use of scientific technology and current trends in the measurement and monitoring of shipping emission have been studied for their applicability in Pakistan.

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Keywords: Green Shipping, Greenhouse Gases, Pollution, Emissions, Sea, Air Quality, Sensors, Coastal Areas.

1. Introduction

Shipping facilitates most of the international trade and is often termed as more environmentally friendly as compared to other modes of transportation. [1] Maritime transport has grown rapidly and significantly in recent decades as worldwide commerce and economic demands have increased. Furthermore, with ports available all over the world, marine transport is currently the most economical means of transportation for crossing long distances and for carrying huge amounts of merchandise[2].

Ships, like all modes of transportation, emit pollutants, most notably carbon dioxide, which contributes to global climate change and ocean acidification [3]. Shipping is still significantly reliant on polluting fuels, accounting for about 2% of global greenhouse gas (GHG) emissions in 2020. Transportation-related CO_2 emissions globally have increased dramatically, beginning at 2.84 billion $GtCO_2$ in 1970 and rising to 7.64 billion $GtCO_2$ by 2021, owing to the growth of both global populations and economies.[4] Since emissions from shipping sector occur in different parts of the world, it is difficult to infer which country is the largest polluter in the sector, however, global shipping, if it were a country, would be the world's eighth-largest carbon dioxide emitter[5]. The considerable growth in global shipping activity has amplified the creation of harmful contaminants[6].

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[1] Adil Tawfiq, Mohamed Mansour, and Ahmed El-Taybany, "ASSESSMENT OF THE EMISSIONS FROM SEAGOING SHIPS IN SUEZ CANAL," *Port-Said Engineering Research Journal* 21, no. 2 (September 1, 2017): 128–37, https://doi.org/10.21608/pserj.2017.33301.

[2] Anthony Sardain, Erik Sardain, and Brian Leung, "Global Forecasts of Shipping Traffic and Biological Invasions to 2050," *Nature Sustainability* 2, no. 4 (March 18, 2019): 274–82, https://doi.org/10.1038/s41893-019-0245-y.

[3] Zheng Wan et al., "Pollution: Three Steps to a Green Shipping Industry," *Nature* 530, no. 7590 (February 2016): 275–77, https://doi.org/10.1038/530275a.

[4] https://www.statista.com/topics/11288/shipping-emissions-worldwide/#topicOverview, accessed on 12 October 2023.

[5] https://greenshippingchallenge.org/ , accessed on 12 October 2023.

[6] Iftikhar Hussain et al., "Estimation of Shipping Emissions in Developing Country: A Case Study of Mohammad Bin Qasim Port, Pakistan," *International Journal of Environmental Research and Public Health* 19, no. 19 (January 2022): 11868, https://doi.org/10.3390/ ijerph191911868.

While cleaner fuels are gaining popularity, transportation businesses continue to rely on fossil fuels like marine gas oil and heavy fuel oil. Marine fuel oil of low quality has 3,500 times more sulfur content as compared to road diesel; hence ports contribute significantly to air pollution issues in coastal areas. The emissions of hazardous gases and particles expose coastal communities to substantial health and environmental risks. Exhaust gas emissions are becoming a more pressing public concern in the context of the merchant marine industry. Port emissions arise from a variety of sources, including fuel-powered ships, cargo handling gear, harbor craft, heavy vehicles for carrying cargo and rail locomotives, port administration automobiles, power plants that provide electricity for seaports processes, and so on.[7] Ship emissions from maritime power plants are directly tied to a set of factors representing engine utilization, namely: propulsion and auxiliary machinery, fuel utilized, combustion temperature, cruise speed, and navigation phases.

Heavy Fuel Oil (HFO) combustion emits hazardous gasses such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), all of which contribute to the problem of climate change. Ships also emit sulfur oxides (SO_x) emissions, which, while not directly affecting climate, offer major environmental and health problems.[8]

In terms of greenhouse gas (GHG) emissions, carbon dioxide (CO_2) is the most significant pollutant. The concentration of atmospheric CO_2 is continuously increasing, owing primarily to manmade activities, and if it continues to climb at the current rate, around 1.5 degrees Celsius of global warming could be reached by the middle of this century, resulting in more climate extremes.[9] While GHG emissions from the shipping industry have been increasing,

[7] Amanda Comings, "How the Push for Cleaner Air Dirtied the Water: The Shipping Industry and Its Impact on the Environment," *California Western International Law Journal* 53, no. 2 (April 1, 2023), https://scholarlycommons.law.cwsl.edu/cwilj/vol53/iss2/10.

[8] Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K.L. Ebi, F. Engelbrecht, J.Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou, 2018: Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

[9] https://greenshippingchallenge.org/

sulfur dioxide (SO_2) emissions have been decreasing since 2009 due to sulfur content regulations in marine fuels.[10] The shipping sector's emission can be broadly classified into two categories;

- **Gaseous pollutant emissions:** Ships visiting ports utilize heavy fuels, which release atmospheric pollutants such as carbon dioxide (CO_2), sulfur oxides (SO_x), nitrogen oxides (NO_x), and other gases. Furthermore, land vehicles used in ports including trucks, rails, buses, and freight handling equipment emit pollutants like NO_x and CO_2.

- **Particulate Matter (PM) and dust:** Ships and other port operations including loading and unloading processes, generate dust and suspended particulates that contribute to air pollution, particularly while handling materials such as coal, minerals, and grain.[11]

Due to global climate change, emissions from shipping operations have attracted substantial attention in industrialized nations during recent years, while governments and port authorities of developing countries are trying hard to address this immediate and catastrophic issue.[12] This increase focus on emissions from shipping sector is primarily because of a growing demand for reduced global emissions in all sectors to meet the goals of Paris Agreement. Besides, the fact that the shipping sector is one of the fastest growing sectors in terms of GHG emissions, makes it imperative for the world to transform to greener shipping operations. In parallel, many ports around the world have introduced policies and regulations to mitigate these emissions.[13]

[10] https://www.statista.com/topics/11288/shipping-emissions-worldwide/#:~:text=International%20shipping%20emissions%20had%20a,transportation%20CO%E2%82%82%20emissions%20that%20year.BB

[11] https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/sustainable-gas-institute/SGI-can-natural-gas-reduce-emissions-from-transport-WP4.pdf

[12] Azfar Hussain et al., "Spatiotemporal Temperature Trends over Homogenous Climatic Regions of Pakistan during 1961–2017," *Theoretical and Applied Climatology* 153, no. 1 (July 1, 2023): 397–415, https://doi.org/10.1007/s00704-023-04484-3.

[13] Hulda Winnes, Linda Styhre, and Erik Fridell, "Reducing GHG Emissions from Ships in Port Areas," *Research in Transportation Business & Management*, Energy

Recently, International Maritime Organization (IMO) member states updated the "IMO GHG Strategy 2023", committing to reach net-zero GHG emissions by the year 2050 and establishing interim reduction goals of 20% by 2030 and 70% by 2040, compared to 2008 levels.[14] This enhanced strategy, while not legally binding in itself, is supported by enforceable and legally binding measures such as the Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII), which took effect in 2023 under an amendment in the MARPOL treaty of 1980. Countries must ensure that their fleets comply with these standards as many member countries may deny port entry to non-compliant vessels. While scientifically advanced countries are moving towards greener shipping, which would help in significantly reducing the emissions at sea, the developing and underdeveloped countries are finding it exceedingly hard to transition to greener shipping. One of the obvious reason is non access to technology but the other underlying factor is the financial constraint in order to afford new and expensive technology.

In the prevalent global emphasis on climate change and spotlight being directed on the shipping sector, it has become necessary for Pakistan to monitor its shipping sector emissions. This situation demands taking measures to transform the country's shipping operations to conform to international standards and introduction of cleaner fuel for the ships, among other necessary measures. This study aims to analyze the situation of air quality over the major ports of Pakistan, using remote sensing and Geographic Information System (RS and GIS) techniques by employing satellite data for pollutants. Furthermore, the study would explore scientific methods like low-cost sensors that are being used worldwide to monitor air quality and emission status at ports and their applicability in Pakistan.

2. Research Methodology

2.1 Study Region

The study focuses on the coastal regions of Pakistan, as shown in the Figure 1. Five major ports of Pakistan have been

Efficiency in Maritime Logistics Chains, 17 (December 1, 2015): 73–82, https://doi.org/10.1016/ j.rtbm.2015.10.008.

[14] https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx

selected for this study, for monitoring the concentrations of key atmospheric pollutants in the region (depicted in Table 1).

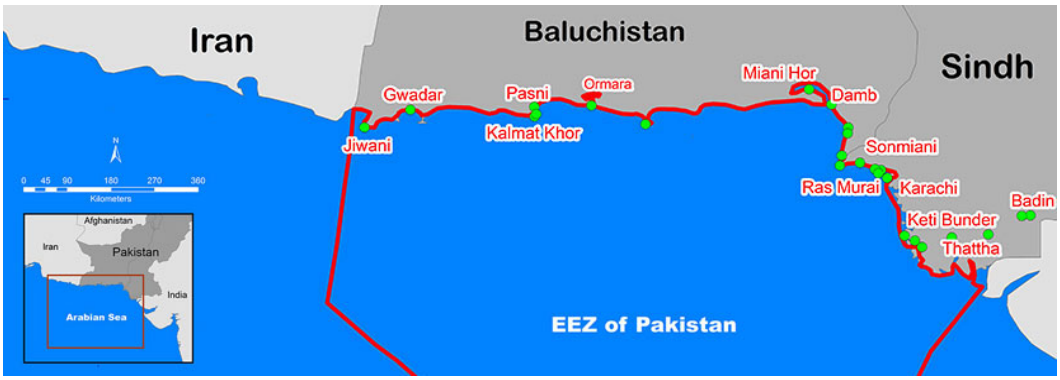

Figure 1. Map of coastal areas of Pakistan (Source: SUPARCO Pakistan, https://suparco.gov.pk/products-services/coastal-and-marine-resources/)

Table 1. Ports of Pakistan included in the study.

Port	Latitude	Longitude
Karachi Port	24.83 N	66.98 E
Muhammad bin Qasim	24.76 N	67.33 E
Gwadar	25.11 N	64.34 E
Ormara	25.2 N	64.67 E
Keti Bandar	24.14 N	67.45 E

2.2 Datasets

The parameters selected to evaluate and monitor air quality of the coastal regions of Pakistan, based on the major emissions from the shipping sector are:

- Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Particulate Matter sized less than 2.5μm (PM2.5)

All the parameters have been mapped and evaluated by using data from different satellites, based on the spatiotemporal availability of the data over the region. The satellite data that has been used in the study has been detailed below.

i. The TROPOspheric Monitoring Instrument (TROPOMI)

Satellite remote sensing is a technique extensively used to monitor atmospheric levels of pollutants worldwide.[15] [16] The TROPOspheric Monitoring Instrument (TROPOMI), was launched on 13 October 2017. It was a joint project of the Netherlands and Europe Space Agency (ESA) and is a UV to shortwave infrared backscattering sensor on board the sun-synchronous Sentinel-5 Precursor (S5P) satellite with an overpass time of 13:30 local solar time. The S5P works to acquire atmospheric composition and monitor air quality including pollutants such as Ozone ($O_{3)}$, carbon monoxide (CO), Nitrogen Dioxide ($NO_{2)}$, Sulphur Dioxide (SO_2), Methane (CH_4), formaldehyde (HCHO) and aerosol properties. With a wide swath of 2600 km and an unprecedentedly high horizontal resolution of 3.5 km×7 km, (3.5 km×5.5 km since 6 August 2019) TROPOMI achieves daily global coverage, which makes it suitable for daily air quality monitoring worldwide.[17]

ii. OMI

This study employs columns of tropospheric NO_2 retrieved from Ozone Monitoring Instrument-OMI onboard NASA's EOS-Aura satellite. OMI was launched in July 2004 and circles the Earth in a sun synchronous, near-polar path. It passes the equator at 13:40 local time and works in three spectral channels between 264 to 504 nm at an average spectral resolution of 0.5 nm. The spatial resolution is about 13 × 24 km^2 at nadir. If there is no technical hindrance, OMI can image the complete globe once every 24 hours. OMI measures ozone, aerosols, clouds, surface UV irradiance, and trace gases including NO_2, SO_2, using UV electromagnetic spectrum bands. OMI, before the launch of TROPOMI, had been used broadly to study the atmospheric

[15] C. A. McLinden et al., "Improved Satellite Retrievals of NO_2 and SO_2 over the Canadian Oil Sands and Comparisons with Surface Measurements," *Atmospheric Chemistry and Physics* 14, no. 7 (April 9, 2014): 3637–56, https://doi.org/10.5194/acp-14-3637-2014.

[16] N. A. Krotkov et al., "Aura OMI Observations of Regional SO2 and NO2 Pollution Changes from 2005 to 2014," preprint (Gases/Remote Sensing/Troposphere/Chemistry (chemical composition and reactions), October 1, 2015), https://doi.org/10.5194/acpd-15-26555-2015.

[17] Chunjiao Wang et al., "Comparison and Validation of TROPOMI and OMI NO2 Observations over China," *Atmosphere* 11, no. 6 (June 2020): 636, https://doi.org/10.3390/atmos11060636.

properties and characteristics at both regional and global levels and collected more than a decade of important data[18].

iii. Measurements Of Pollution In The Troposphere (MOPITT)

MOPITT is a remote sensing instrument onboard NASA's Earth Observing System Terra spacecraft, which measures and records tropospheric carbon monoxide (CO) on the global scale[19]. MOPITT has been operational since March 2000. MOPITT capacities have enabled the scientific investigations about the prevalence, transportation, sources and sinks of CO. CO is a trace gas produced by breakdown of methane, fossil fuel consumption and biomass burning. This study utilises CO data from MOPITT from 2010 to 2021 to map concentrations around the area of interest.

iv. Copernicus Atmospheric Monitoring Service (CAMS)

Particulate Matter consists of solid and liquid particles that are directly emitted into the atmosphere because of diesel use, road and agricultural dust, and industrial activity.[20] $PM_{2.5}$ is composed of tiny particles with size less than 2.5 μm that are emitted directly into the atmosphere and secondary particles produced by chemical reactions between precursor gases. PM serves as a significant potential danger to human health. $PM_{2.5}$ due to its small size, is inhaled in through the respiratory system and further infiltrate the lung alveoli to reach the bloodstream causing a myriad of serious diseases.[21] It may cause serious health issues for workers and even residents in port areas. Fine dust and black carbon emitted from fuel burning and coal handling is known to cause damage to ship equipment and expensive naval installations nears the coastal areas.

Copernicus Atmosphere Monitoring Service (CAMS) provides operational daily analysis and forecast of aerosols including PM2.5

[18] Wang, Chunjiao, Ting Wang, Pucai Wang, and Vadim Rakitin. “Comparison and Validation of TROPOMI and OMI NO2 Observations over China.” *Atmosphere* 11, no. 6 (June 2020): 636. https://doi.org/10.3390/atmos11060636.

[19] https://www2.acom.ucar.edu/mopitt

[20] Prakash Thangavel, Duckshin Park, and Young-Chul Lee, “Recent Insights into Particulate Matter (PM2.5)-Mediated Toxicity in Humans: An Overview,” *International Journal of Environmental Research and Public Health* 19, no. 12 (June 19, 2022): 7511, https://doi.org/10.3390/ijerph19127511.

[21] Thangavel, Park, and Lee.

since 2016.[22] The daily data from CAMS has been used for this study for the time period of 2016-2022.

3. Results and Discussions

3.1 Nitrogen Dioxide (NO_2) Trends over Coastal Areas of Pakistan

Nitrogen oxides (NO_x = NO + NO_2) are critical gaseous contaminants found in the troposphere. NO_x plays a role in the production of ozone (O_3) and particulate matter leading to increased levels of oxidants in the troposphere, which affect air quality and human health. [23] Tropospheric NO_2 emissions are further characterised as anthropogenic and natural sources. Burning of fossil fuels is by far the most dominant source of NOx, especially in and around urban areas. Additionally, biomass burning, lightning and soil emissions are also eminent causes of NO_2 formation.[24] The use of fossil fuels in shipping sector make them a source of NO_x as well, causing NO_x pollution in port cities.

Figure 2 represents the concentration of NO_2 over the coastal zones of Pakistan during 2010, 2015 and 2022. Although the concentrations of NO_2 have shown a decline in 2015 and 2022 as compared to 2010, they are still present in significant amounts around port cities. Karachi port was the port with highest NO_2 concentration in 2010 while Muhammad bin Qasim Port recorded the highest concentrations in 2015 and 2022. The Karachi Port is the largest deep seaport of Pakistan. Owned by the Ministry of Maritime Affairs and managed by the Karachi Port Trust (KPT), it handles nearly 60% of national shipments while Port Qasim is the second busiest port of Pakistan handling about 35% of the nation's cargo[25] and both ports naturally serve as considerable source of emissions. These emission concentrations for five major ports are depicted in Table 2.

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[22] Bozzo, A., S. Remy, A. Benedetti, J.Flemming, P. Bechtold, M.J. Rodwell, and J.-J. Morcrette, 2017: Implementation of a CAMS-based aerosol climatology in the IFSA. ECMWF Technical Memorandum 801, 33 pp

[23] Gerard Hoek et al., "Long-Term Air Pollution Exposure and Cardio- Respiratory Mortality: A Review," *Environmental Health* 12, no. 1 (May 28, 2013): 43, https://doi.org/ 10.1186/1476-069X-12-43.

[24] Wang et al., "Comparison and Validation of TROPOMI and OMI NO2 Observations over China."

[25] https://www.marineinsight.com/know-more/major-ports-in-pakistan/

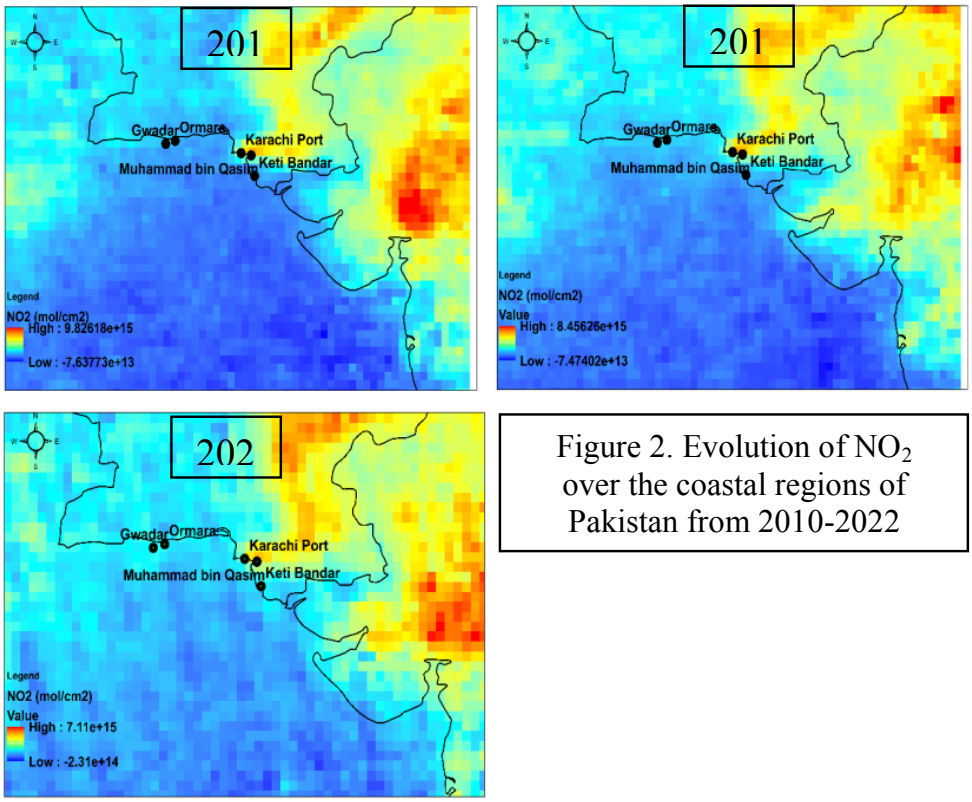

Figure 2. Evolution of NO_2 over the coastal regions of Pakistan from 2010-2022

Table 2: Concentrations of key pollutants at each of the selected ports during the study period

NO2 (mol/cm2)	2010	2015	2022
Karachi Port	6.78E+15	1.73E+15	1.08E+15
Muhammad bin Qasim	4.48E+15	2.42E+15	2.19E+15
Gwadar	9.82E+14	8.58E+14	8.75E+14
Ormara	1.25E+15	9.19E+14	8.58E+14
Keti Bandar	1.45E+15	6.98E+14	6.93E+14
SO2 (DU)	2010	2015	2022
Karachi Port	0.09	0.16	0.11
Muhammad bin Qasim	0.13	0.09	0.08
Gwadar	0.04	0.05	0.01
Ormara	0.05	0.05	0.02
Keti Bandar	0.03	0.002	0.04
CO (mol/cm2)	2010	2015	2022
Karachi Port	1.91E+18	1.87E+18	2.11E+18
Muhammad bin Qasim	1.91E+18	1.87E+18	2.11E+18
Gwadar	1.81E+18	1.73E+18	1.9E+18

Ormara	1.67E+18	1.83E+18	1.95E+18
Keti Bandar	1.78E+18	1.97E+18	2.08E+18
CO2 (ppm)	2010	2017	---
Karachi Port	389.75	402.37	---
Muhammad bin Qasim	389.75	402.37	---
Gwadar	390.18	402.76	---
Ormara	390.18	402.76	---
Keti Bandar	389.75	402.37	---

3.2 Sulphur Dioxide ($SO_{2)}$ Trends over Coastal Areas of Pakistan

Sulphur dioxide is mainly emitted into the atmosphere as a result of combustion of fossil fuels that contain sulphur, such as coal and oil. In the coastal areas, it is mainly emitted from fuel containing sulphur in ships and other shipping operations.[26] SO_2 emissions are the highest at Karachi port followed by Muhammad bin Qasim Port. However, these emissions are not very high at the region, because these concentrations are averaged over the year. There is a possibility of isolated SO_2 spikes related to an accident but overall, SO_2 concentrations were not identified as being significant over the region. Figure 3 depicts the map of SO_2 over the study region.

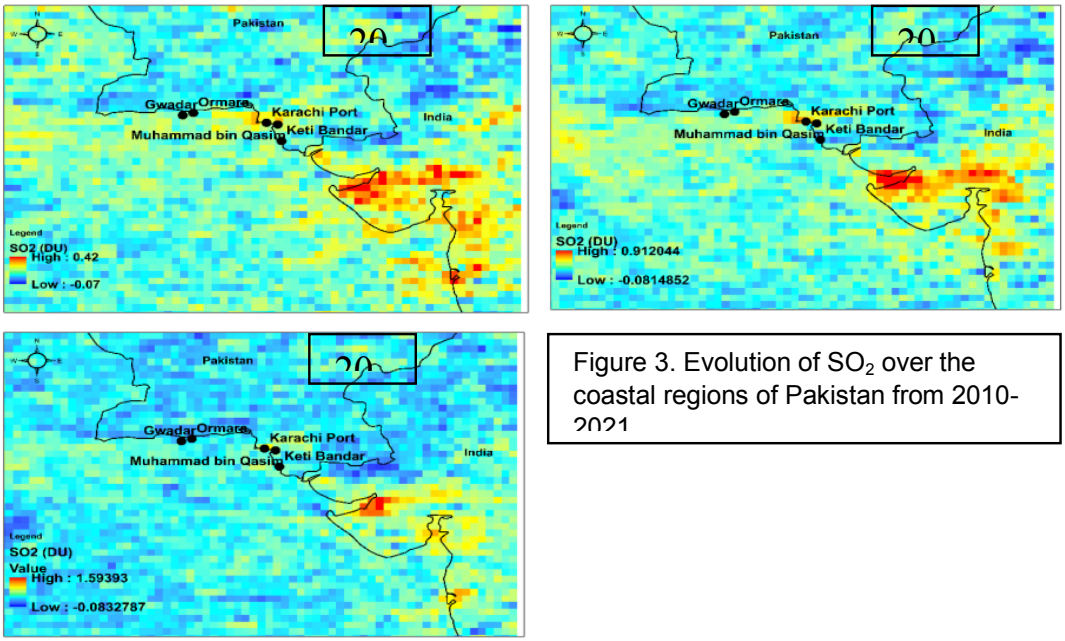

Figure 3. Evolution of SO_2 over the coastal regions of Pakistan from 2010-2021

[26] Tawfiq, Mansour, and El-Taybany, "Assessment of the Emissions from Seagoing Ships in Suez Canal."

3.3 Carbon Monoxide (CO) Trends over Coastal Areas of Pakistan

Carbon monoxide (CO), which is released into the air due to incomplete combustion of fossil fuels, biomass burning and forest fires, is an important criteria pollutant included in ambient air quality standards.[27] The CO released into the atmosphere impacts human life and plays a role in global warming as well. Exposure to high levels of carbon monoxide over a long period of time can lead to respiratory and cardiovascular diseases, developing of neuropsychiatric conditions and other illnesses and can even be fatal. CO accumulation in residential and industrial units has caused deadly accidents in the past in Pakistan, therefore it is widely known to be a hazardous gas even in small concentrations.

Results of CO concentrations mapping over coastal area of Pakistan showed that the concentrations increased in 2022 as compared to 2020 and 2015. The highest concentrations of CO were recorded at largest ports i.e., Karachi port and Muhammad bin Qasim Port in 2010 and 2022, while Keti Bandar port had the highest concentration of CO in 2015.

[27] Anis Asma Ahmad Mohtar et al., "Variation of Major Air Pollutants in Different Seasonal Conditions in an Urban Environment in Malaysia," *Geoscience Letters* 5, no. 1 (September 11, 2018): 21, https://doi.org/10.1186/s40562-018-0122-y.

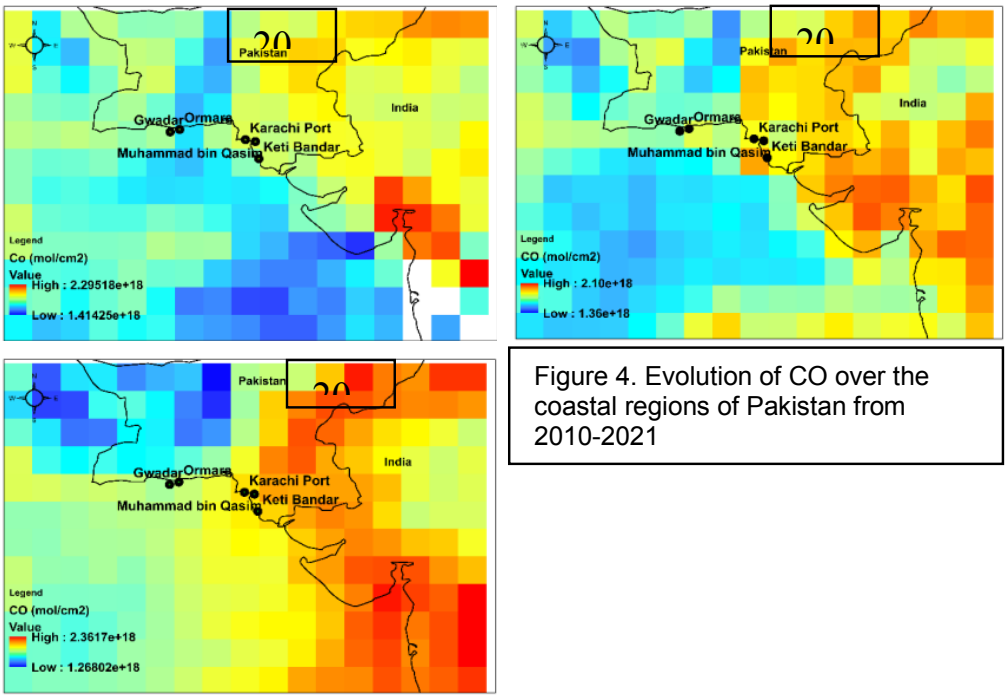

Figure 4. Evolution of CO over the coastal regions of Pakistan from 2010-2021

3.4 Carbon Dioxide (CO_2) Trends over Coastal Areas of Pakistan

CO_2 is the most potent gas responsible for global warming and it is one of the highest pollutants of the shipping sector. Worldwide shipping emissions contributed 1 billion tonnes of CO_2 in 2018 alone and were accountable for around 2.9% of total anthropogenic emissions[28]. A study by Hussain et al[29] estimated pollutant emissions at the Muhammad bin Qasim port of Pakistan and concluded that container ships are the largest emitters of air pollutants, followed by tankers. According to the study the main reason for container ships' maximum emissions is the engine powers and emission factors associated with residual oil fuel. It was also noted in the study that CO_2 had the highest percentage in emission totals in the shipping sector (more than 92% of the total), since it is the primary byproduct of burning fossil fuel. CO_2 has a long half life and stays in the atmosphere for almost a century, thus once emitted, it is not easy to sequester it.

[28] https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-shipping-sector_en

[29] Hussain et al., "Spatiotemporal Temperature Trends over Homogenous Climatic Regions of Pakistan during 1961–2017."

Despite being the primary pollutants caused by shipping operations, it is hard to identify the CO_2 emission source by remote sensing techniques as it is a well-mixed gas with a long half-life in the atmosphere. Hence remotely sensed CO_2 concentrations in any area would conform to the global trends, as depicted in the Figure 5. In situ observations are more suitable for measuring on point source emissions of CO_2.

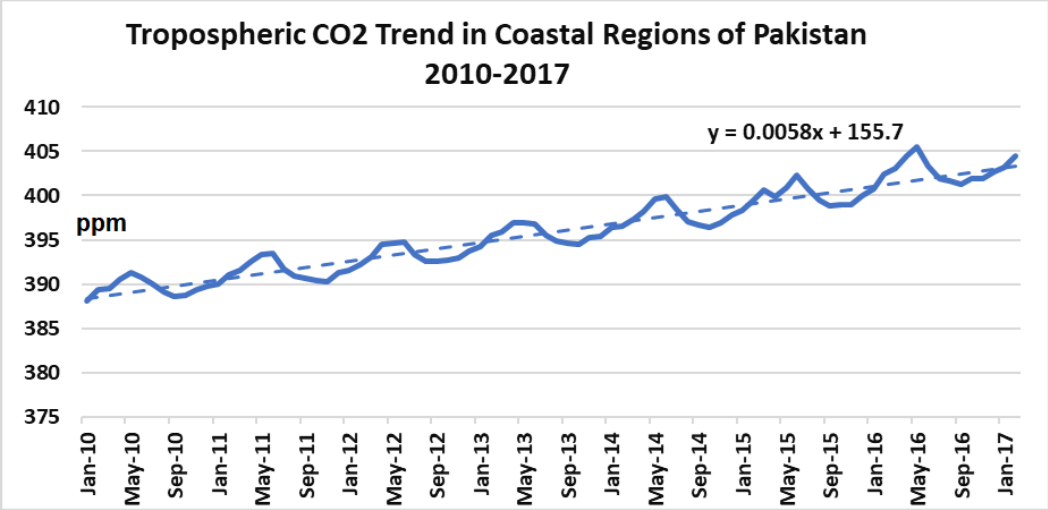

Figure 5. CO_2 Concentration during 2010-2017 over coastal regions of Pakistan

3.6 Particulate Matter (PM2.5) over Coastal Areas of Pakistan

Particulate matter emissions from shipping sector are responsible for up to 14% of PM2.5 concentrations found in coastal regions of Europe for up to 25% in shipping hotspot areas. It has been observed that switching to cleaner fuels for ships not only resulted in considerable reductions in shipping-source-related $PM_{2.5}$ at a port site but also at an urban background site.[30]

PM2.5 concentrations taken from CAMS website, were analysed during 2016 and 2022 using the CAMS satellite data as this was the temporal range of data available. PM2.5 has a decreasing trend in the particulate matter as shown in Figure 6. However, these values still remain much higher than the ambient air standards of

[30] Eunhwa Jang et al., "Impact of Shipping Emissions Regulation on Urban Aerosol Composition Changes Revealed by Receptor and Numerical Modelling," *Npj Climate and Atmospheric Science* 6, no. 1 (May 29, 2023): 1–13, https://doi.org/10.1038/s41612-023-00364-9.

WHO which cap the PM2.5 measures under 35µg/m^3 for 24 hours average and 75 µg/m^3 for annual average.[31] The decreasing trend might be due to use of low sulphur fuel in ships during recent years. According to another study over Karachi, the PM_{10} and $PM_{2.5}$ readings are often two to three times higher than the air quality standard requirements.[32]

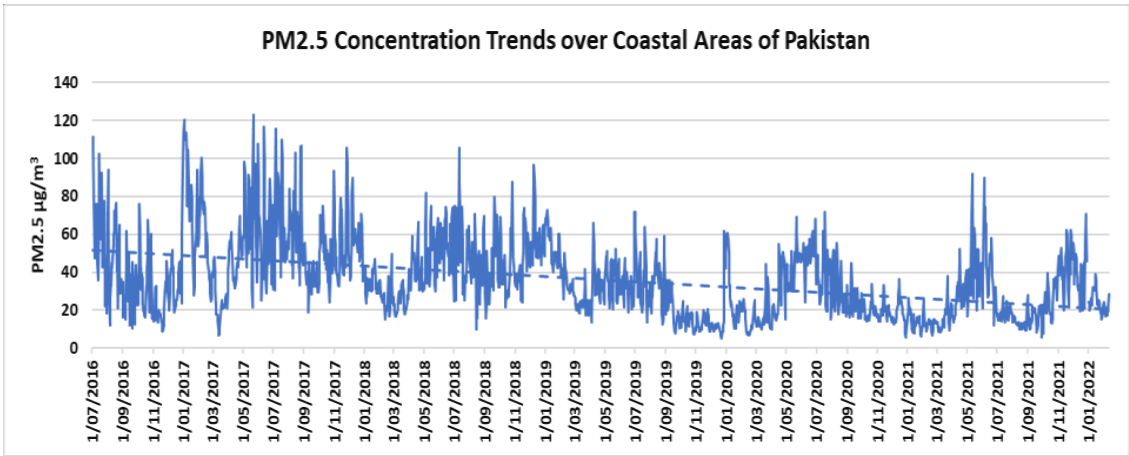

Figure 6. PM2.5 concentration during 2016-2022 over coastal regions of Pakistan

3.7 Current Technological trends in Measurement of Shipping Emissions

In order to assess the effect of ships traffic and harbour operations on air quality and atmospheric composition to plan efficient mitigation strategies, there is a growing need for reliable scientific measurement tools. Rapid development of new technologies in recent years has opened various avenues for real time monitoring of ship emissions and their effect on air quality. Some of these techniques are discussed in this section, which can be useful for air quality monitoring and regulating emission at ports of Pakistan as well.

In Pakistan Pakistan Environmental Protection Agency (Pak EPA) and provincial EPAs are mandated to monitor environmental parameters

[31] https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en_US#:~:text=For%20PM2.5%20these%20are,m3%2024%2Dhour%20mean.

[32] Mohammad Idrees, Yasmin Nergis, and Muhammad Irfan, "Industrial Emission Monitoring and Assessment of Air Quality in Karachi Coastal City, Pakistan," *Atmosphere* 14, no. 10 (October 2023): 1515, https://doi.org/10.3390/atmos14101515.

and pollutants. Emerging technologies in air emissions from port operations and shipping sector can be measured by provincial EPAs and port authorities, in close coordination with agencies like Pakistan Maritime Security Agency (PMSA), Pakistan National Shipping Corporation (PNSC) and other relevant bodies.

Low-cost sensors at ports

A system based on the incorporation of air quality measurements taken by using a network of low cost sensors with local-scale dispersion modelling can be a handy monitoring tool for port areas for measuring emissions. Experiments have proved that such can be operated in near-real-time as well as in forecast mode, and on archived data for long-term assessments as explained in the study by authors. [33]

Portable exhaust monitoring devices

Portable exhaust monitoring devices can be useful for measuring emissions from mobile sources such as marine traffic and over vast expanses of sea. A portable device can be mounted on drones, patrol boats, docks, bridge cranes, or other maritime equipment, to carry out all-weather and real time monitoring of emissions from ships. The device utilises suction to sample and measure the content of pollutants in the exhaust gas and can transmit the results to a cloud server using 4G transmission.[34]

On-board solutions

There are various on-board tools developed in recent years for ships to measure and clean the exhaust from the ships. These include marine exhaust analysers, marine and shipping emission controllers, exhaust cleaners and scrubbers among others. One recent development in the field is to use and complement the data from the Automatic Identification System (AIS) trackers that all ships carry.

[33] Eva Merico, Adelaide Dinoi, and Daniele Contini, “Development of an Integrated Modelling-Measurement System for near-Real-Time Estimates of Harbour Activity Impact to Atmospheric Pollution in Coastal Cities,” *Transportation Research Part D: Transport and Environment* 73, no. 0 (August 2019), https://trid.trb.org/view/1633602.

[34] Fan Zhou et al., “A Real-Time Measurement-Modeling System for Ship Air Pollution Emission Factors,” *Journal of Marine Science and Engineering* 10, no. 6 (June 2022): 760, https://doi.org/10.3390/jmse10060760.

Connecting ships' AIS data of location and speed with parameters like engine power and fuel consumption rate can calculate a composite view of carbon emissions of a ship.[35]

Advancements in satellite technologies

Satellite remote sensing of air pollutants has been in practice since many decades but measuring point sources of ship pollution were not very accurate because of atmospheric dynamics and diverse satellites' properties. In recent years, European Space Agency's Sentinel 5 satellite has been experimented successfully to measure the concentration of NOx in shipping lanes. Now efforts tare in line to put up a satellite specifically for the macro-monitoring of CO_2. There is optimism about the initiative, and it is being hoped that that the new, carbon-tracking satellite would be in orbit sometime in the current decade, providing yet another scientific means for checking the health of the planet.[36] In Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) is the leading body working on satellite technology development for applicability in Remote Sensing data products, agriculture, forestry, disaster management, water resources, environment, urban planning and management, coastal and marine resources and management etc.[37]

4. Conclusions

The study investigates the status of key shipping emissions on the coastal areas of Pakistan and scientific methods that can be employed for monitoring and containment of the pollutants. It is observed that NO_2 and SO_2 concentrations have not shown a significant increase from 2010 levels despite an increase in the shipping traffic and operations, which can be attributed to stricter international regulations pertaining to use of low sulphur fuel. CO and CO_2 concentrations have risen in the last decade in the coastal regions of Pakistan. PM2.5 concentrations have decreased in the time span of 2016 to 2022, however they still remain above the allowable limits of WHO.

[35] https://www.wartsila.com/insights/article/pollution-police-how-are-ship-emissions-monitored

[36] https://www.wartsila.com/insights/article/pollution-police-how-are-ship-emissions-monitored

[37] https://suparco.gov.pk/

Human health and environmental impacts of shipping sector are huge and need to be taken seriously in developing countries like Pakistan, where they are often overlooked. Monitoring and measurement of ship emissions face challenges in the realm of scientifically organizing ship emissions data, data acquisition, transmission, and analysis, as well as information services for local population and policy makers. Hence, novel insights and understanding among the key stakeholders in government, industry, and civil society should be developed to facilitate cross-sectoral engagements, necessary for the effective implementation of international and national regulations pertaining to shipping sector and easier transition to green shipping.

The technologies involved are no doubt expensive, but the dividends are high; we must protect the environment for our future generation. In the case of environmental monitoring in Pakistan, policy formulation and laws do exist but there is a need for implementation and enforcement.

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IUU Fishing policy adoption in Pakistan: An overview

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Abstract

Several initiatives have been taken to fight against IUU fishing globally. In a recent development FAO has developed a new agreement to prevent IUU fish catch reaching to the ports. In this context, Regional Fisheries Organizations have a key role in the fight against illegal fishing in their territorial waters. However, many east African and southwest Indian Ocean states do not pay attention to adopt IUU prevention measures. They should have no history of IUU activities and are subject to inspections during the arrival and amp; landing of fish. In this research, we provided three types of forms for the various measures are prescribed in the model scheme. The Application (form A) for Port Access for foreign fishing vessels should be submitted 72 hours before the arrival of the Vessel. Information on fishing trips, vessel characteristics, VMS, quantities of fish on board, and other documentation should be provided. The name of the vessel is verified to ensure that it does not appear on the list of IUU. For tuna and tuna-like species, the name of the vessel is checked against the positive list of the Indian Ocean Tuna.

1. Introduction

Despite several initiatives taken to fight against IUU no significant achievement made to address the issues properly and implement regulations. The efforts for ensuring traceable and transparent fishing mostly exist at all times governed by global directives e.g FAO Compliance Agreement (1993)[1], The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (in force since 2001). However, the

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[1] https://www.fao.org/iuu-fishing/international-framework/fao-compliance-agreement/en/

problem of illegal fishing mainly started when many more corrupt people quested for short-term gains at the stake of sustainable fishing and environmental practices. To arrest the situation and its global impact, FAO initially presented the International Plan of Action to Prevent, Deter, and Eliminate IUU Fishing (IPOA-IUU).Nevertheless, IPOA-IUU was developed as a voluntary instrument, within the framework of the Code of Conduct for Responsible Fisheries. The IPOA-IUU identifies responsibilities for all States (flag States, coastal States, port States), in applying agreed market measures. The plan called for bilateral, regional, and international cooperation[2] to deal with IUU fishing. This was especially the case for shared fisheries that required coordination in between countries.

Subsequently, FAO adopted a new agreement to prevent IUU fish from entering ports through an effective mechanism in the form of the Port State Measures Agreement to Prevent, Deter, and Eliminate IUU fishing. It is firmly believed that if the parties, in their respective capacities as port States, apply the Agreement in true letter and spirit then things can be improved considerably by Sustainability Foundation.

2. Methodology

The methodology employed in this study is based on a comprehensive literature review, analysis of international agreements, and examination of regional initiatives. Case studies from Mozambique and Mauritius were included to provide practical insights into the implementation of anti-IUU measures. The data for trends and capacities in IUU fishing were obtained through a survey conducted by WWF-Pakistan in 2013, focusing on monitoring, surveillance, and control capabilities in Indian Ocean countries.

3. Regional initiatives

RFMOs, mostly referred to as Regional Fisheries Organizations, have a key role in the fight against IUU fishing. As regional or sub-regional organizations responsible for the sustainable management of fishery resources in a particular region of international waters, RFMOs maintain lists of IUU vessels thus enabling them to take enforcement action when required. Different countries have

[2] Personnel communication with SFI team at SFI HQs (Hamburg, Germany) on 14 September2015.

different obligations due to countries' dynamics or due to the RFMOs they are a party to, certain gaps are created that are then exploited by IUU operators. The main loophole is that the regional focus of port state measures allows IUU-listed vessels to move to other regions to avoid sanctions. RFMOs also have problems concerning their consensus approach.[3] Figure 3 indicates the geographical location of respective RFMOs and regional fisheries bodies (RFBs).

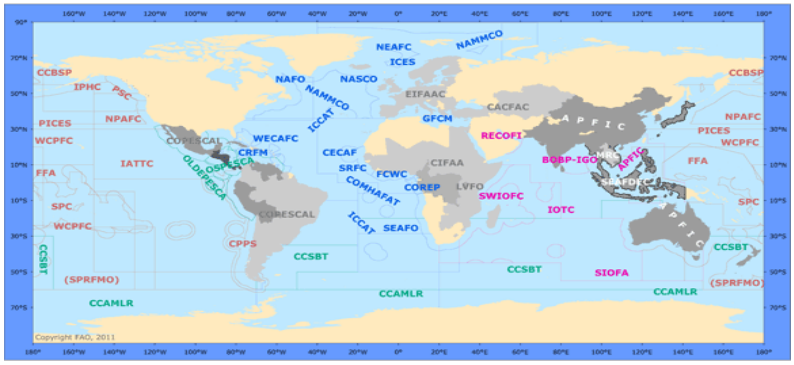

Figure 3: Regional Fisheries Management Organizations and Bodies (Source: FAO)

In 1948 the Indo-Pacific Fisheries Council, now the Asia-Pacific Fishery Commission (APFIC), was set up under the FAO Constitution. Since then, other regional bodies or arrangements have been established within and outside the framework of FAO. According to the FAO, currently, there are 44 regional fishery bodies worldwide, 20 of which are Regional Fisheries Management Organizations (RFMOs).[4]

The functions of RFBs vary but the difference between a "regional fishery body" and a "regional fishery arrangement" is that the former has established a Secretariat that operates under a governing body of member States and the later does not have.[5] Two main regional initiatives, such as SEAFDEC and the IOTC, have played pivotal roles in implementing IUU measures. Additionally, the Port

[3] J. H. (2011, February 10). The Piracy-Illegal Fishing Nexus in the Western Indian Ocean. Retrieved July 1, 2015, from http://www.academia.edu/6737362/The_Piracy 3 Illegal_Fishing_Nexus_in_the_Western_Indian_Ocean Indian Ocean Research Programm

[4] Personnel communication with PieroMannini Senior Liaison Officer Fisheries and Aquaculture Departmentduringfield studytripto FAO(Rome)inApril 2015

[5] FAO. (2013, October 17). FAO Fisheries & Aquaculture - What are RFBs? Retrieved from http%3A%2F%2Fwww.fao.org%2Ffishery%2Ftopic%2F16800% 2Fen

State Measures Agreement (PSMA) of the FAO is analyzed for its significant impact on combating IUU fishing.

4. Fish-i-Africa

Most East African and southwest Indian Ocean states do not pay sufficient attention to growing maritime threats, including IUU. Their response mechanism to maritime safety and security is immature mainly due to weak governance, a lack of maritime domain awareness a lack and most importantly the political will to undertake this gigantic task. Although most of the nations are signatories to various International Maritime Organization conventions and protocols, however, many have failed to take concrete measures to ratify these truly.[6]

To address the issue of IUU in the Western Indian Ocean region of South-eastern Africa, a regional partnership has been made recently. The initiative has been developed through a partnership between the five coastal States of Comoros, Kenya, Mozambique, Seychelles, and the United Republic of Tanzania, the Stop Illegal Fishing working group of the NEPAD (The new partnership for Africa's development) Planning and Coordination Agency (NPCA), and the Pew Environment Group. These partners will work to build cooperation, information- sharing and analytical systems between the key Southeast African coastal states to prepare them for targeted enforcement actions against IUU fishing operators in the Western Indian Ocean. Further cooperation with regional partners such as the Indian Ocean Tuna Commission (IOTC) and the Indian Ocean Commission (IOC) is also committed. The partner countries have agreed to establish a platform for real-time data sharing of sensitive information about vessels, their movements, catch, and owners, intended to enable nations to take timely action against suspected illegal operators. ("Stop Illegal Fishing," n.d.).

5. Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission has been successful in recent years (IOTC). The IOTC has adopted several new resolutions

[6] J. H. (2011, February 10). The Piracy-Illegal Fishing Nexus in the Western Indian Ocean. Retrieved July 1, 2015, from http://www.academia.edu/6737362/ The_Piracy 6 Illegal_Fishing_Nexus_in_the_Western_Indian_Ocean Indian Ocean Research Programme

initiated by the EU. For example, the adoption of a Port State Control and Inspection Scheme that reflects the FAO Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing. The Secretariat of the Indian Ocean Tuna Commission (IOTC) provides support to the Commission, its members, and cooperating non-contracting parties in several ways. The requirement for providing support may stem directly from obligations elaborated directly into specific Conservation and Management Measures or maybe more general, as the Commission or its Committees may find necessary ("The Commission," n.d.)

The IOTC adopted a positive record-keeping method for Authorized vessels in 2002. The IOTC also maintains a record of active vessels. This includes all vessels that the flag state has determined to have been active in the previous year. This record contains additional information (to the IOTC record of authorized vessels) from the port and licensing states on vessels that have used their port or requested a license. The record of active vessels can be useful in obtaining information regarding IUU vessel movements and their subsequent activities.

According to the framework of the IOTC Record of Authorized Vessels, there is an explicit requirement for the IOTC Executive Secretary to maintain the IOTC Record of Authorized Vessels (RAV) and to take necessary measures to ensure publicity of the Record through electronic means, including placing in the IOTC website (Mr Umair, personal communication). To meet the requirements of this responsibility, the Compliance Section of the Secretariat has the responsibility for maintaining and publishing the IOTC Record of Authorized Vessels.

Members and Cooperating non-contracting Parties that authorize their vessels under the requirements for creating the IOTC Record of Authorized Vessels are responsible for providing information on their vessels, which includes vessels ‘particulars and periods of authorization, to the Executive Secretary. Following the first entry of a vessel into the Record, Members and Cooperating non-Contracting Parties, are also required to communicate any changes in the particulars of their vessels to the Executive Secretary, for updating the Record. Following any update of the Record, Members or Cooperating non-contracting Parties are routinely advised to verify the record for their respective vessels. It is, therefore, incumbent on the

flag State to keep the Executive Secretary informed of changes in the status of their authorized vessels[7]

The RAV faces many challenges. These are:

- Completeness of information – no vessel details are provided or are available.
- Vessels with expired authorizations may continue to operate.
- Vessels in operation with back-dated authorization periods.
- Vessels may be exporting controlled species, but not listed in the RAV.
- The existence of the major Taiwanese fleet, but Taiwan is not a member of the IOTC thus considered a major difficulty.

Various authorities may consult the RAV:

- Flag States to ensure the veracity of information for their fleet.
- Coastal States for licensing purposes
- Port States to investigate port calls by foreign vessels and.
- Market States to review access to the markets.

6. Salient Analysis of Port State Measures

The 2009 FAO Agreement on Port State Measures to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing had its origins in the 2005 FAO Model Scheme on Port State Measures to Combat Illegal, Unreported, and Unregulated Fishing that was endorsed by the Committee on Fisheries (COFI) at their 2005 session. The 2005 FAO Model Scheme was non –binding and intended for there enforcement of the implementation of the IPOA–IUU.

The PSM Agreement indicated several dynamics that include many irresponsible States operating open registries, offering “flags of non-compliance”. It also reflected the International intolerance of flag States over their failure or reluctance to employ active governance over vessels flying their flags under international law. Further, the agreement comprehended that port State measures in respect of

[7] Personnel Communication M.K.DG (Retd) Marine Fisheries Department, Pakistan, January,2015).

fishing vessels should be expanded given their lack of existence in international law.

Table 4: Status of Ratification of the 2016 FAO Port States Agreement

No.	Country	No.	Country	No.	Country
1	Albania	26	Grenada	51	Panama
2	Angola	27	Guinea	52	Peru
3	Australia	28	Guyana	53	Philippines
4	Bahamas	29	Iceland	54	Republic of Korea
5	Bangladesh	30	Indonesia	55	Russian Federation
6	Barbados	31	Japan	56	Saint Kitts and Nevis
7	Benin	32	Kenya	57	Saint Vincent and the Grenadines
8	Cabo Verde	33	Liberia	58	Sao Tome and Principe
9	Cambodia	34	Libya	59	Senegal
10	Canada	35	Madagascar	60	Seychelles
11	Chile	36	Maldives	61	Sierra Leone
12	Costa Rica	37	Mauritania	62	Somalia
13	Cuba	38	Mauritius	63	South Africa
14	Côte d'Ivoire	39	Mexico	64	Sri Lanka
15	Denmark (in respect of Greenland and the Faroe Islands - Associate Member)	40	Montenegro	65	Sudan
16	Djibouti	41	Morocco	66	Thailand
17	Dominica	42	Mozambique	67	Timor-Leste
18	Ecuador	43	Myanmar	68	Togo
19	Eritrea	44	Namibia	69	Tonga
20	European Union – Member Organization	45	New Zealand	70	Trinidad and Tobago

21	Fiji	46	Nicaragua	71	Türkiye
22	France (in respect of overseas territories)	47	Nigeria	72	United Kingdom
23	Gabon	48	Norway	73	United States of America
24	Gambia	49	Oman	74	Uruguay
25	Ghana	50	Palau	75	Vanuatu
			76	Viet Nam	

Source: FAO, Rome Fisheries and Aquaculture Department (Last update: June-2016)

The 2016 Agreement embodied the deeply concerned, conscious, and well-recognizing material, with an explicit intent to avert, discourage, and eradicate IUU fishing through the implementation of effective port State measures. In its General Provisions, it defines its use of terms, its Objective and Application, the relationship with international law and other international instruments, Integration and coordination at the national level, Cooperation and exchange of information, etc. It also defines the desired conditions for a vessel's entry into the Port, the designation of ports, and advance requests for port entry.[8]

The role of Flag States and requirements of developing states are discussed and the process of dispute settlement including the peaceful settlement of disputes. The responsibilities of non-parties and several other general issues are also discussed. The Agreement has five Annexes addressing requirements for Port inspection, measures, and guidelines for the training of inspectors.

The status of Ratifications and progress toward entry into force are shown in the following table 4.

The efforts for achieving sustainable development in fisheries are rooted to a greater or lesser extent in all international fisheries

[8] F. (2010). FAO/UNEP Expert Meeting On Impacts of Destructive Fishing Practices, Unsustainable Fishing, And Illegal, Unreported And Unregulated (IUU) Fishing on Marine Biodiversity And Habitats (Rep. No. FAO Fisheries and Aquaculture Report. No. 932.). Retrieved June 30, 2015.

instruments concluded to date. While the 1982 UN Convention does not refer specifically to port State measures as a fisheries management tool in respect of fishing vessels.

Therefore, since 1992 these measures have been seen as a means to enhance fisheries conservation and management and combat IUU fishing. Commencing with the introduction of port State measures as a management tool in the 1993 FAO Compliance Agreement, they evolved and strengthened progressively to the point where an internationally binding agreement on port State measures was concluded in 2010.[9]

7. Trend and Capacity Analysis in IUU

To examine the trend and capacity in IUU fishing in some of the Indian Ocean countries WWF- Pakistan undertook a survey monkey in Dec-2013. The objective of the survey was to gain updated information and knowledge about intrinsic monitoring, surveillance, and control capabilities in the Indian Ocean and to identify resource needs, support, and action for dealing with unregulated fishing. The survey also focused on the current status of the management of fishing capacity and how countries in the region are addressing IUU fishing. The purpose of the survey was to identify and adequately address core components of transparent and traceable fishing in the Indian Ocean, and through the common lens while looking at survey findings participants could determine the commonalities (challenges and solutions) to counter IUU fishing. The survey was built on current and past studies undertaken by WWF on the following:

- Monitoring fishing vessel AIS data
- Mapping Trade Flows from Selected East African Fisheries
- Mapping study of initiatives and organizations in Africa involved in fisheries MCS work
- Transparency Gap Analysis for selected Southwest Indian Ocean (SWIO) countries and
- Trade Data Analysis to identify possible IUU trade flows

[9] Doulman, D. J., & Swan, J. (2012, January). A guide to the background and implementation of the 2009 FAO agreement on port state measures to prevent, deter and eliminate illegal, unreported and unregulated fishing. FAO Fisheries & Aquaculture Circular, (1074), 1. Retrieved September 9, 2015, from Edb.

The survey analysis chalked out various areas for a concerted and coordinated approach to be adopted to fight against the problem of IUU. These included the capacities of coastal states to deter IUU at

a) the national level, and b) the regional level. The survey identified that if benefits are to be gained it has to come from strengthening regional cooperation, communication, and information, in particular to pool resources while aiming to deter IUU to coastal states that have limited MCS capacities. A detailed monkey survey is placed in Appendix C

8. Measures to curb IUU- Mozambique Case Study in Regional Perspectives

Mozambique became a full member of the Indian Ocean Tuna Commission (IOTC) in 2012.[10] Since then, has been actively taking part and contributing to the implementation of all the IOTC resolutions to Prevent, Deter, and Eliminate IUU fishing activities in the region such as:

- Resolution 05/03 – on the establishment of an IOTC program of inspections in port
- Resolution 06/03 – on the establishment of a vessel monitoring system and
- Resolution 10/11 – on Port State Measures.

All foreign vessels are obliged to send an entry request that shows their entry point, date, time, catch onboard by species, and weight to <entryexitcatchmoz@gmail.com> 48 hours before entering the Mozambican EEZ. The same procedure is required when the vessel leaves the Mozambican EEZ. The information sent by the vessel is cross-checked with VMS data and other information sources if needed. Catch reports showing reported position, species, and weight are required every three days for cross-checking against logbooks and VMS of reporting positions. Licenses are only given in port after a satisfactory inspections. The vessel cannot fish until the inspection at the port is complete. The Ministry of Fisheries has designated Maputo, Beira and for pre-fishing inspections: all vessels must report to one of these ports. After inspection, inspection reports are scanned and sent to the IOTC Secretariat within three days,

[10] https://www.fao.org/3/bg894e/bg894e.pdf

according to the IOTC Resolution 10/11 and relevant countries. Vessel briefing and inspection in port involves:

- The ship's Agent
- Immigration
- Customs
- Health
- Port Authority and the
- Ministry of Fisheries – National Directorate of Fisheries Law Enforcement

Pre-fishing inspection in Mozambican ports is mandatory for all fishing vessels (domestic and foreign) to check the technical characteristics of the vessel, log books, catch onboard, and fishing gear and for briefing the master on rules and procedures for fishing in Mozambique EEZ and issuing of the fishing license. It is the Mozambican view that this largely contributes to reducing IUU fishing. In 2012, 32 foreign tuna vessels were inspected in Mozambican ports - five European Union purse seiners in the Port of Nacala, six Seychellois purse seiners (Nacala), and 21 Japanese longliners in Maputo.

This program presents some challenges. Some vessels ship private armed security guards, and Mozambique is designing a strategy for the entry/exit of these vessels. Not all fishing vessels agree to enter in ports allegedly because of the cost, rather they request that inspectors are sent for pre-fishing inspections to a third country or sea. There is a need to share inspection reports through the Southern African Development Community region and to promote joint inspections. There are no inspectors in Nacala, and they must be sent from other regions when required. (Maria Eulalia.National Deputy Director Maputo, Personal communication, August 5, 2015).

The headquarters of the Secretariat of the Southwest Indian Ocean Fisheries Commission (SWIOFC) which currently has twelve Members: Comoros, France, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Seychelles, Somalia, South Africa, United Republic of Tanzania, and Yemen, was moved from Harare to Maputo. The transfer was based on the commitment that Mozambique has shown to the sustainable use of resources in the Western Indian Ocean region. The Mozambique Minister of Fisheries, Mr Víctor

Manuel Borges, and the Food and Agriculture Organization's Assistant Director-General for Fisheries and Aquaculture, Mr Árni Mathiesen, have signed a Host Agreement of the SWIOFC Secretariat. At the ceremony, on behalf of the Government, Víctor Manuel Borges said that the signature of this Agreement is "an important step that shows Mozambique's commitment towards the regional cooperation in fisheries".[11]

9. Mauritius -Case Study in Regional Perspectives

Mauritius has amply demonstrated to the international community its willingness to combat IUU fishing, and capacities to implement a relevant sectoral policy. There are powers for control over international fleets calling at Port Louis and over the fishing zone given with the adoption in 2010 of a National Plan of Action against IUU fishing. Under the EU/IOC MCS program, Mauritius has since 2007 positively contributed to combatting IUU fishing through regional surveillance and sea patrols including Port State Control.

The Regional Fisheries Surveillance Plan (RFSP) for the South Western Indian Ocean is considered to be the main tool of the regional strategy for fisheries monitoring of the Indian Ocean Commission (IOC), an organization comprising the Comoros, Réunion, Madagascar, Mauritius and Seychelles. The tuna regional fisheries are vital to the economies and food security of IOC countries, but they span a wide area of ocean, making MCS a challenge.[12]

The fundamental principles underlying the RFSP are political will, regional commitment, and international support. First, in 2005, IOC Heads of State decided to strengthen efforts to fight against IUU fishing. In 2007, the five IOC fisheries ministers signed a regional agreement reflecting the common wish to fight IUU in their EEZs. The Agreement incorporated into a framework partnership with the European Union (Member Organization), under which the latter committed to providing financial and technical support for six years.

[11] Fish-i- Africa. (2014). Fish-i-Africa Media Summary-November 2014 (Rep.). Retrieved August 6, 2015, from http://www.thefishsite.com/fishnews/24573/south-west-indian-ocean11fisheries-commission-moves-to-mozambique

[12] FAQ: What is a Regional Fishery Management Organization? (2012, February 23). Retrieved June 12, 2015, from http://www.pewtrusts.org/en/research-and-analysis/fac 12 sheets/2012/02/23/faq-what-is-a-regional-fishery-management 12 organization

For their part, the ministers made commitments to share existing facilities to monitor and track licensed fishing vessels in EEZs. They also agreed to board and inspect non-licensed fishing vessels in EEZs, by aerial and sea patrols, as appropriate. Four action plans were developed, encompassing joint patrols, data exchange, regional VMSs, and extension to East Africa.

Subsequently, results of the RFSP as of February 2014 include 39 MCS joint patrols, deployment of 350 inspectors at sea, and more than 420 inspections at sea, mainly of fishing vessels that never come to port and are suspected of transshipment. Ten suspects have been arrested and 40 infringements detected. A 2013 report revealed a high number of inspections of vessels from the Taiwan Province of China. These vessels are targeted because they are engaged in transshipment, not because of their origin; there is no discrimination among flag States. On account of these enforcement actions, authorized and licensed fleets are now taking confidence in how IOC countries are managing their EEZs and enabling economic development. Some MCS activities also contribute to fight against piracy. These types of concrete results concerning data exchange, capacity building, trust, and efficiency were unimaginable before 2007.[13]

10. International and Regional Measures adopted by Mauritius

Measures to reduce and curb IUU in Mauritian waters are commendable. Some of the measures adopted by the Mauritian government are discussed in the ensuing paragraph. The information has been gathered from the scientific officer Port Louis (Hansdhwazsing, Bhudoye. Personal communication, July 2015).

The Mauritian Government adheres to the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas and the Agreement related to the Conservation and Management of Straddling and Highly Migratory Fish Stocks of the United Nations Law of the Sea (Fish Stocks Agreement) of 1995.[14] It observes the

[13] FAO. (2015). Fourth Global Fisheries Enforcement Training Workshop (Rep. No. R1078). Retrieved August 7, 2015, from tps://www.google.se/url?url= http://www.fao.org/3/a

[14] https://www.un.org/depts/los/convention_agreements/Background%20paper% 20on% 20UNFSA.pdf

Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) and has ratified the Southern Indian Ocean Fisheries Agreement (SOFA). Mauritius is also a member of the Indian Ocean Tuna Commission. The Mauritian Fisheries and Marine Resources Act (FMRA) has been updated with provisions for international instruments that enable the implementation of resolutions of RFMOs.

There is a Port State Control Unit based in the Port with trained staff that provides a mechanism for monitoring fishing vessels consistent with the FAO Model. Officers have received training on boarding and inspections sponsored by the IOTC and the Smart Fish of the IOC. The VMS scheme is consistent with IOTC regulations and South West Indian Ocean Fisheries Commission (SWIOFC) recommendations.

11. Dealing with IUU Vessels

Access to IUU-listed vessels is denied as vessels involved in any fishing activity in violation of any international fishery conservation and management measures are prohibited from landing or transshipping catches in any Mauritian port. Provision is made in the FMRA banning the transshipment of fish in the maritime zones of Mauritius. Foreign fishing boats or vessels entering or leaving the EEZ have to be informed 24 hours in advance, and fishing vessels should give 72 hours' notice before entering the port. Fishery control officers have to enforce applicable international fishery conservation and management measures to boats and vessels, irrespective of whether they are licensed to fish in the Mauritius maritime zones.

Mauritius has procedures to ensure that fishing vessels calling at Port Louis are not involved in IUU activities and that resolutions of RFMOs are complied with. It undertakes to ensure that services, e.g. landing & departure clearances, for visiting vessels are efficient, convenient, and in line with the FAO Model Scheme. Mauritius monitors local and foreign fishing vessels licensed to operate in the Mauritius EEZ through a Vessel Monitoring System.

Penalties for contravention now range from $1500 to $ 1,000,000 depending on the offense that has been committed. Sections on “Photographic Evidence” and “Observation Devices” have been included in the FMRA to be in line with the IPOA- IUU for evidence and admissibility in court proceedings. All local and foreign

licensed vessels must report their positions, speed, and direction every two hours to the FMC at the Albion Fisheries Research Centre. Vessels should be appropriately marked as per FAO Standard Specifications for marking and identification of fishing vessels. The FMRA also provides for enacting regulations specific to combat IUU fishing activities.

A Port State Control Unit has been set up with a trained staff of one Divisional Scientific Officer, one Scientific Officer, one Senior Technical Officer, one Technical Officer, one Clerical Officer, and five officers of the Fisheries Protection Service. They are assisted by officers of other relevant departments. The main activities are:

- Inspection of all fishing vessels and issue authorizations for unloading of fish both from foreign and local vessels;
- Authorization for vessels entry and leaving.
- Landing Permits for imported fish and fish products; and
- Authorizations of export.

A mechanism in line with the FAO Model Scheme on Port State measures has been set up for vessels so that they must provide advance notification of intention to enter port. They should have no history of IUU activities and are subject to inspections during the arrival & landing of fish.

Three types of forms for the various measures are prescribed in the model scheme. The Application (form A) for Port Access for foreign fishing vessels should be submitted 72 hours before the arrival of the Vessel. Information on fishing trips, vessel characteristics, VMS, quantities of fish on board, and other documentation should be provided. The name of the vessel is verified to ensure that it does not appear on the list of IUU. For tuna and tuna-like species, the name of the vessel is checked against the positive list of the Indian Ocean Tuna.

12. Conclusion:

In conclusion, combating Illegal, Unreported, and Unregulated (IUU) fishing demands a comprehensive, collaborative approach that spans international, regional, and national levels. Regional Fisheries Management Organizations (RFMOs), exemplified by successes like Fish-i-Africa and the Indian Ocean Tuna Commission (IOTC), play a

pivotal role in managing fisheries, maintaining IUU vessel lists, and coordinating enforcement actions. The effectiveness of such regional initiatives underscores the importance of fostering cooperation and information-sharing among nations to address the transboundary nature of IUU fishing. The Port State Measures Agreement by the Food and Agriculture Organization (FAO) represents a significant global effort to curb IUU fishing by establishing robust port State measures. While the increasing number of ratifications reflects a global commitment, challenges persist, including incomplete information and vessels with expired authorizations. Overcoming these challenges requires sustained efforts and continued international cooperation to strengthen the implementation of the agreement and address evolving dynamics in the fight against IUU fishing. At the national level, case studies from Mozambique and Mauritius offer tangible examples of successful measures to curb IUU fishing. Mozambique's mandatory pre-fishing inspections, denial of access to IUU-listed vessels, and regional information-sharing exemplify a proactive approach. Similarly, Mauritius' Port State Control Unit, stringent entry notification requirements, and penalties for contravention showcase effective national-level strategies. These examples underscore the importance of local implementation to supplement broader international and regional efforts, creating a comprehensive framework to combat IUU fishing and protect global fisheries resources.

13. Recommendations

To effectively combat IUU fishing in Pakistan, it is imperative to focus on key recommendations. Firstly, the government should prioritize building knowledge and technical capacity through comprehensive training programs. Secondly, advocating for the ratification of the Port State Measures Agreement (PSMA) in the Western Indian Ocean (WIO) and Northern Indian Ocean (NIO) region is crucial for enhanced regulatory control. Thirdly, promoting information sharing and learning from successful Monitoring, Control, and Surveillance (MCS) practices of other RFMOs can significantly improve regional strategies. Additionally, efforts should be directed towards improving and scaling up existing initiatives, such as Fish-i-Africa, by identifying opportunities for additional funding and partnerships. Lastly, establishing short loan schemes for local fishermen to install MCS on their vessels can address immediate

implementation challenges, with a focus on seeking international support for sustainable fisheries management.

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Environmental Challenges – Focus on Indian Ocean: Evaluation of International Climate Change Agreements and Protocols

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Abstract

Environmental challenges are posing serious threats not only to humanity but to all creatures on Earth. Countering rapid ecological degradation in the last two decades has been a source of serious stress for the international community. According to United Nations Framework Convention on Climate Change (UNFCCC), human imprint is contributing to climate change due to many factors. The retrospective study highlights oil spills, plastic pollution, nuclearization, Illegal Unreported and Unregulated Fishing (IUUF), domestic waste, agricultural waste, and heavy metal pollution as reasons towards environmental degradation and negative impacts on marine ecosystems. Analytical study of international efforts for ecological protection highlights certain limitations to implementing international agreements and protocols. Parties' non-compliance to surrender their sovereignty before international organizations is a serious matter. Such a situation needs revisiting the international attitude towards environmental protection not for the current population but for generations to come. Descriptive research approach employed for comparative analysis of international efforts results in region-specific recommendations. Consent of all participating states to make concrete efforts to save Earth's ecosystem will worth more for action. Regularly revised international regulations and protocols as per circumstantial needs will help to secure seas and maritime environment.

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Key Words: *Basel Convention, Climate Change, International Climate Change Agreements, Illegal Unreported and Unregulated Fishing*

1. Introduction

"The six years since the Paris Climate Agreement have been the six hottest years on record. Our addiction to fossil fuels is pushing humanity to the brink. We face a stark choice: Either we stop it — or it stops us."

UN Climate Change Conference-COP 26

Antonio Guterres- Secretary General

Environmental degradation is defined as introduction of hazardous or toxic elements to our environment and resultant degenerative impact on all life forms and undesirable changes in Earth's atmosphere. This deterioration largely stems from exhaustion of natural resources, toxic release from fossil fuel, overpopulation, destruction of wildlife and other ecosystems. The environmental degradation poses health risks to animal and plant life and has pushed humanity to the verge of an apocalypse. Environmental degradation has also affected world oceans. World governments have contributed towards relieving this undue pressure on environment i.e., emission reduction, population control and helping developing countries overcome environmental problems; however, still massive efforts are needed to do away with this menace.[2]

World oceans are no distant objects but components of all life forms on Earth. From food to stability in the climate, we are dependent on our oceans which are home to the most of Earth's biodiversity. Many of these life forms cater for protein food for one and half billion people. Furthermore, oceans produce 50% of the oxygen in our atmosphere. Above all, world economy is heavily dependent on the oceans. According to estimates, by 2030, approximately 40 million people will have been employed in the sea-based industry.[3] From maritime tourism and trade to fishing and sea-mining, our dependence on the oceans increased exponentially. However, harmful human

[2] Peter B Chambell, "The climate has changed before, But this is different – look at the archeological record," *The Guardian*, November 9, 2017,

[3] UN Web Report, "The Ocean: Life and Livelihoods," *UN. Org*, August 6, 2021,

activities have exacerbated the cycle of degeneration, pressing heavily on the overall health of the oceans.

'Climate Change' "denotes to long-term change in the statistical distribution of weather patterns (e.g., temperature, precipitation etc.) over decades to million years of time. Climate on Earth has changed on all time scales even since long before human activity could have played a role in its transformation.[4] But UNFCCC[5] defined Climate Change as" "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." However, the IPCC definition of Climate Change includes change due to natural variability alongside human activity [6] Australian Government's DCCEE.[7] Webpages describe Climate Change- as 'our climate is changing, largely due to the observed increases in human produced greenhouse gases."

Greenhouse gases "absorb heat from the sun in the atmosphere and reduce the amount of heat escaping into space. This extra heat has been found to be the primary cause of observed changes in the climate system over the 20th century. Thus, in the environmental discourse different stakeholders have characterized Climate Change as mainly the change in modern climate augmented by human activities. The adverse human activities for example burning fossil fuel, deforestation etc. are considered likely to bring change in some climatic aspects. "AIP[8] maintains that the rise of environmentalism in the early 1970s raised public doubts about the benefits of human activity for the planet which in other way turned the curiosity about climate into anxious concern. Since then, concern about anthropogenic global degradation spreads which ignited numbers of international cooperation, programs and meeting of

[4] Chambell, 2017.
[5] UNFCC Web, "Fact Sheet: Climate Change science – the status of climate change science today," *UNFCC*, 2023,
[6] UNFCC Fact Sheet, 2023
[7] Annual report, Coordination and Reporting of Australia's Climate Measures," *ANAO.Gov*, April 20, 2010,
[8] Spencer R. Weart, *The Discovery of Global Warming* (Harvard University Press: 2009).

concerned stakeholders including representatives from interested community other than the scientist only.[9]

Programs and meetings in 70s appear to take place to explore and acknowledge the extent of anthropogenic Climate Change. Global Atmospheric Research Program (GARP) organized by World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) in 1974 are relative example. Examination of the highly complex problem of the physical basis of Climate change: a theoretical review of climate.[10] Another example could be the first World Climate Conference (WCC) organized by the WMO in 1979.

Whereas some significant events in 1980s and 90s, can be said, were inclined to devise methods to address it. For example, Montreal Protocol of the Vienna Convention in 1987 imposes international restrictions on emission of ozone destroying gases. Two major events in 1990s, one, '92 conference in Rio-de-Janeiro produces UN Framework Convention on Climate Change and another '97 International conference produces Kyoto Protocol (came into effect in 2005) that set targets for industrialized nations to reduce greenhouse gas emissions.[11] Kyoto Protocol is regarded the most significant commitment in addressing Global Climate Change so far. That's why as it expires at the end of 2012, through different conventions, from UNFCCC to Conference of the Parties (COP-17) to the convention, held in November–December 2011 in Durban, South Africa, the world nations are continuing to strive to negotiate what may become the post-Kyoto.[12] Within latest Conference of Parties (COP-26) decides, resolve to pursue efforts to limit the temperature increase to 1.5 degrees C, which gives this lower temperature threshold even greater emphasis than in the Paris Agreement.[13] In addition, the pact asks nations to consider further actions to curb potent non-CO2 gases, such as methane, and includes language emphasizing the

[9] Weart, 2009.
[10] H. Flohn, "Climate and energy: a scenario to a 21st century problem," *Climatic Change* 1, no. 1, (1977): 5-20.
[11] Weart, 2009.
[12] Sheila M. Olmstead and Robert N. Stavins, "Three key elements of a post-2012 international climate policy architecture," Review of Environmental Economics and Policy 6, no.1 (2012): 65-85,
[13] Press Brief, "COP-26: Key outcomes agreed at the UN climate talks in Glasgow," *Carbon Brief*, November 15, 2021,

need to phase down unabated coal and phase-out fossil fuel subsidies.[14]

Literature review highlights that due to technological advancements and industrial revolution development in maritime sector is observed. In contrary, this progress ends up in varied and more complex nature of pollutants and grave impact on maritime climate. International protocols and agreements need to be updated as per changing scenarios and global climate status. Moreover, all signatory states need to abide by the set rules to keep global environment survivable for generations to come. Research discussion ahead evaluate international climate protocols and highlights area of improvement.

2. The Indian Ocean

The third largest body of water in the world and surrounded by one of the most densely populated areas, the Indian Ocean is strategically one of the most important geographical entities. It is bounded on the West by Africa and Arabian Peninsula, on the North by Southern Asia, on the East by Sunda islands and Australia and on the South by the Southern Ocean. The impact of environmental degradation is more pronounced in the Indian Ocean both due to anthropogenic and geographical factors. The Indian Ocean, surrounded from three sides by the most populous areas in the world, has been crucially important for trade for the regional as well as extra regional people. Indian Ocean is where a huge load of world's containerized traffic carrying goods and commodities passes through. This large-scale trade activity has also resulted in more pollution in the ocean. Startling statistics say that the introduction of pollutants and rise of water level are more rapid in the Indian Ocean than anywhere else. [15] Majority of surrounding coastal states are underdeveloped and this too has added to the ever-growing environmental hazards in the area.

Reasons behind pollution and warming of the Indian Ocean are diverse, largely natural, and anthropogenic. From overpopulation, failure to meet objectives of ratified agreements on environment,

[14] *Carbon Brief, 2021*

[15] News Report, "Indian Ocean warming at higher rate than other oceans, says IPCC report," *Business Insider*, August 9, 2021,

destruction of ecosystems, coral reef and other plant and animal life, oil spillage and nuclearization are the most pressing concerns.

3. The Nature Of Environmental Problems Affecting The Oceans

The nature of factors affecting our oceans are diverse and many. Major environmental problems are as under:

3.1 Oil Spill

Oil spill from ships is damaging to environment and ocean ecosystems. Connecting Africa, East Asia and Middle East with Europe, the Indian Ocean provides vital sea routes for international trade. Heavy traffic carrying petroleum and related products cross these important sea routes. Large reserves of oil and gas are found in Arabian Peninsula, India, Iran and Australia and estimates show that a staggering 40% of the world's offshore oil and gas supply comes from the Indian Ocean. This is, however, not without any downsides to it. Oil spill in the Indian Ocean has caused more damage to the ocean health than anywhere in the world. It has been estimated that around 106 tonnes of petroleum and related products are discharged in the Indian Ocean annually. From 1975 to 1988, 38 tanker and non-tanker incidents were recorded.[16] Oil spill from ships causes serious damage to environment by destruction of marine life. Recent incidence of massive oil spillage in Mauritius can have serious impact on environment for decades to come.[17]

3.2 Plastic Pollution

The Indian Ocean receives 15 million tonnes of plastic waste annually.[18] This threatening amount of plastic will remain in the Ocean for next one thousand years before it degenerates. Surrounded by densely populated developing coastal states, the Indian Ocean receives 1 trillion pieces of plastic each year and has become the second most polluted ocean after North Pacific.[19] It is needless to say that this plastic pollution results in destruction of marine life. According

[16] Tayyab Saify and S.A. Chaghtai, "Source of Pollution in Indian Ocean – Risk and Management," *Chemical Spills and Emergency Management at Sea*, (1988): 479,
[17] UNEP Report, "How to manage the damage from oil spills," *UN Environment Programme*, October 7, 2021,
[18] Prasad Kariyawasam, "A Healthy Indian Ocean feeds, protects, and connects all South Asians," *World Bank Blogs*, March 30, 2021,
[19] Kariyawasam, 2021.

to UNESCO data, approximately, one million marine animals die from plastic waste per year in the oceans which is alarmingly high.[20]

3.3 Nuclearization

Recently, due to India's ambitious program, the Indian Ocean has become nuclearized. It gives rise to proliferation and safety risks. Commenting on AUKUS deal, Dr Green described the plan as "tantamount to putting floating Chernobyl's in the heart of Australia's cities."[21] Reactor accidents and release of radioactivity into the water during normal operations and maintenance are dangerous for environment.[22] Thus, nuclearization of the zone will add to the gravity of the environment issues in the Indian Ocean.

3.4 Illegal Unreported And Unregulated Fishing (IUUF)

As of 2018, IUUF was a 23.5 billion[23] trade on the global black market. IUUF is not only a grave threat to fish stock but is also damaging for ocean environment and can potentially injuring or killing one odd criminal is not threat to environment unless those are killed in millions at one time. The Indian Ocean is home to 14% of global wild fish catch.[24] However, the use of explosives, harmful fishing gear and large-scale illegal fishing has not only resulted in diminishing fish stock, but also in destruction of marine ecosystems such as coral reefs. A breakthrough report by WWF has found regulatory gaps in the existing legal frameworks for fisheries. These gaps have caused intensified illegal fishing activity adding to the worsening environmental conditions in the Indian Ocean.[25]

3.5 Domestic Waste

Domestic waste contains organic substances like nitrogen and phosphorus. This matter is required by the marine ecosystems;

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[20] Report, "Facts and Figures on Marine Pollution," *UNESCO.Org*, 2023,
[21] Daniel Keane, "Nuclear-powered submarines have 'long history of accidents', Adelaide environmentalist warns," *ABC News*, September 17, 2021,
[22] Thomas Curren, "Nuclear Powered Submarines: Potential Environmental Effects," *IAEA.Org*, October 1988,
[23] SLF Report, "Blast Fishing in the Indian Ocean," *Stop Illegal Fishing*, April 18, 2018, https://stopillegalfishing.com/press-links/blast-fishing-in-the-indian-ocean/
[24] WWF, "Unregulated Fishing on the high seas of the Indian Ocean," *WWF.EU*, November 2, 2020,
[25] WWF, 2020

however, excess of this can have negative impact and can cause imbalance in environment. Moreover, excess nitrogen and phosphorus can cause over-fertilization known as eutrophication. This over-fertilization can result in the profuse growth of a particular type of algae limiting the diversity in the species.

Domestic wastes also contain large amounts of inorganic matter. In smaller amounts, this matter is essential for growth of animal and plant life, but uncontrolled and excess discharge of such waste into sea can cause serious damage to environment. Coastal tourism is a thriving industry worldwide and unsustainable tourism practices too add greatly to the environmental issues related to oceans.

3.6 Agricultural Waste

Survival conditions wage a war on insects, weeds, and pests. As per a study of 88 countries conducted by International Fertilizer Industry Association (IFADATA), in timeline of 1961-2010, these countries used 110 million tonnes of fertilizers per year.[26] China used the most fertilizer, i.e. 21.6 million tonnes each year followed by United States 17.6 million tonnes per year. On average, eighteen countries consumed more than one million tonnes fertilizers annually. [27] Out of this huge quantity, approximately 25% can expectedly reach the marine environment and cause severe damage to marine ecosystem. Agriculture waste contaminates the ocean water, deplete oxygen concentration, yield algae bloom which leads to disruption of entire marine ecosystem due to creation of dead zones.

3.7 Heavy Metal Pollution

Marine pollution caused by oil and related products has long been in the limelight in media and research organizations. Yet, there are other forms of pollution with more threatening impact on marine environment. One such source of pollution is toxic heavy metals. Sources of this pollution are both natural and anthropogenic. Natural causes include underwater volcanic eruptions, etc. and human activities include submarine metal ores and petroleum extraction.

[26] Yongbo Liu, Xubin Pan and Junsheng Li, “A 1961-2010 record of fertilizer use, pesticide application and cereal yields: a review,” *Agron Sustained Development* 35, (2015): 84.
[27] Liu, et. al., 2015.

The list, however, cannot be limited only to these two reasons. It also involves river runoff, industrial and domestic discharges of heavy metals from under-sea mining of minerals and metals for industrial use. These under-sea human activities result in introduction of significant amounts of heavy metals in the marine ecosystems where these toxic metals remain for a long time. Some of these metals causing damage to ocean ecosystem health are mercury, cadmium, and lead. Consumption of fish contaminated by these heavy metals has resulted in spread of diseases.

Very much like most of the organic pollutants, these metals cannot be degraded chemically or biologically. They can change their oxidation state after long exposure to ocean water; however, they cannot be removed from there. It is alarming to note that a few metals having undergone chemical reactions produce such products as are high in toxicity. These inorganic pollutants can alter enzyme-related natural magnification in the food chain hierarchy.[28] This causes plants and animals become a serious health hazard when consumed.

This massive pollution from varying sources has contributed to exponential deterioration of environment and is thus posing serious health risks to plant and human health. It has affected the health of the ocean largely in the form of marine life destruction. Many of the species of fish and other marine animals have sustained damage due to worsening environmental conditions.

Most of the coral reefs in the Indian Ocean have been declared as endangered species. Large patches of coral reefs have disappeared due to massive use in the cement industry.[29] Many forms of marine vegetation, such as mangroves, have also sustained damage. Mangroves are immensely important for ocean ecosystem health. They are home to many species of fish, crabs, and prawns. However, mangroves along the coastal areas are fast diminishing which can have serious consequences for environment.

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[28] Mobin Siddiqi and Rafia Azmat, “The Arabian Sea – Marine Pollution Viz A Viz Existence and Implementations of International Preventative Laws,” *Polaris – Journal of Maritime Research* 1, no. 1 (2019), 70. https://bahria.edu.pk/polaris/the-arabian-sea-marine-pollution-viz-a-viz-existence-and-implementation-of-international-preventative-laws/

[29] R. Sen Gupta and S.Y.S. SIngbal, “Marine Pollution in the Indian Ocean: problems, prospects and perspectives,” *Journal of Fisheries Association* 18, (1988): 342,

At present, overexploitation of seafood stock, depletion of coral reef, oil spillage from ships, troughing of pollutants and toxins into the ocean and the like, have wreaked havoc and if this continues, there will be no future.

4. International Protocols And Agreements On Environmental Degradation

International Environmental Agreements (IEAs) are signed treaties that regulate or manage human impact on the environment to protect it. The number of environmental conventions has increased 38-fold worldwide since enforcement of Stockholm Convention in 1972. World governments and non-governmental organizations have contributed towards checking marine pollution and its impact on environment. Some of the most notable conventions/agreements/ international protocols regarding environmental degradation are as under:

4.1 Ramsar Convention

Signed in 1971 in Ramsar, Iran, Ramsar Convention is the only international protocol that focuses only on wetlands. The convention mandates the participants/members to adopt National Wetland Policies based on the concept of 'wise use'. By 2018, more than 2300 wetland areas were included in Ramsar List.[30]

4.2 London Convention and London Protocol

Signed in 1972 the convention on the prevention of marine pollution by dumping of waste and other pollutants is also known as the London Convention. It is one of the first international protocols for the conservation of the marine environment from harmful human activity. The convention applied to the deliberate disposal of waste into ocean from vessels, aircraft or any other platform. In 2006, this convention transformed into a new, free standing and more protective treaty. London Protocol strictly prohibits the transport and disposal of hazardous waste into the sea.[31]

[30] UN Water, "Ramsar Convention on Wetlands," *UN Water.Org*, 2023,
[31] EPA Report, "Ocean Dumping: International Treaties," *EPA.Org*, 2023,

4.3 Kyoto Protocol

Oceans exert a major influence on climate system. For decades, the oceans have trapped 93% of excess heat produced by excess greenhouse gases [32] Signed in 1997, Kyoto Protocol addresses the issue by mandating the members to cut back on their carbon emissions.

4.4 The International Convention for the Prevention of Pollution of the Sea by Oil (1954)

This convention prohibits the deliberate disposal of certain hazardous elements into the oceans, including oil wastes, dredging and land-produced waste, excluding the oil pollution caused by usual operational discharge of ships. Pakistan and Afghanistan are parties to the convention.[33]

4.5 MARPOL Convention

The Convention for the Prevention of Pollution from Ships (MARPOL) is dedicated to prevention of marine pollution produced by the operational discharge of oil and other hazardous substances and to curtail the discharge of such harmful chemicals and substances[34] (MARPOL is divided into different Annexes according to different categories of contaminants, each of which regulates different types of emissions from ships. All these Annexes have so far been ratified by a number of nations.

4.6 Basel Convention

1989, the United Nations Environment Programme (UNEP) adopted the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal. Basel Convention is the first effort to establish an agreement on international standards to control the dumping of harmful toxins. Plastic, produced on land, eventually makes its way to the oceans. Given the colossal amount of plastic dumped in the oceans, Basel Convention's 2019

[32] Yassir A. Eddebbar, Natalya D. Gallo, and Lauren B. Linsmayer, "The Ocean and UN Framework Convention on Climate Change," *ASLO Pubs*, July 15, 2015,

[33] Mobin Siddiqi and Rafia Azmat, "The Arabian Sea – Marine Pollution Viz A Viz Existence and Implementations of International Preventative Laws," *Polaris – Journal of Maritime Research* 1, no. 1 (2019), 70.

[34] IMO, "MARPOL," *IMO.Org*, 2023

plastic waste amendment deals with the menace of dumping of plastic into the world oceans.[35]

4.7 Paris Agreement

First adopted in December 2015 by 196 parties at during COP 21 in Paris, the Paris Agreement emerged as a legally binding international treaty on climate.[36] Enactment of the Paris Deal demands social and economic transformation, centered on the available scientific knowledge and technology. This international protocol functions on a five-year cycle of perpetually ambitious climate action executed by the countries. The Blue Cop was held in Madrid, Spain. A principal outcome of this conference was an agreement to conduct an Ocean and Climate Change Dialogue as a part of the UNFCCC Climate Dialogues. In December 2020, the dialogue was conducted online. The dialogue emphasized on the existence of a strong link between the climate and world oceans. and the need to continue to find opportunities to bolster ocean-climate action within the UNFCCC, in future COPs as well as across UN agencies.

4.8 Stockholm Convention

The Stockholm Convention is an international treaty aiming to safeguard environment and human health from the impact of persistent organic pollutants (POPs). The Convention entered into force on May 17, 2004.[37]

This Convention, currently regulating 29 POPs, makes it imperative on the parties to adopt certain control measures to reduce or eliminate 29 POPs. For the POPs produced on purpose, the Convention requires parties to prohibit their production and usage. The Stockholm Convention also requires parties to limit trade activity in such matter. As for unintentionally produced POPs, the Convention asks parties to develop national action plans to check releases and to apply “Best Available Techniques” to restrict them. The Stockholm Convention also endeavors to ensure the management of stockpiles and waste containing POPs.

[35] Basel Convention, “Amendments of Annexes II, VIII, and IX, to the Basel Convention,” *Basel Int*,
[36] UNCCC, “The Paris Agreement,” *UN. Org*, 2023,
[37] UNCCC, 2023.

5. International Protocols And Their Limitations

We have hundreds of international laws and protocols enforced, yet there have always been gaps between legislation and implementation of such environmental protocols. Such efforts have been under-resourced, poorly coordinated and faced lack of implementation methods. Lack of political will also impacts efforts for climate change and emission reduction. In fact, we have never had such a great number of international protocols and treaties; however, climate change, soil erosion and other harmful human activities are increasing steadily. Every year treaties are signed, objectives are set, but the will to implement any plans is not there. Generally, these treaties are not binding enough to ensure compliance and practical application to any useful level.

As mentioned earlier, many international protocols to address environmental degradation have been framed and enforced; however, so far none has made it to any substantial mark. Kyoto Convention, for example, is considered to have failed due to inherent structural flaws, short timeframe of action and binding targets with regards to emission reduction.[38] Kyoto Protocol was actually bound to fail from its inception as it didn't involve the largest and fast expanding economies. It excluded developing countries from stringent objectives and the USA didn't sign it up. The protocol aimed at reducing global emission and thereby keep global warming and rising sea levels in check; however, the last decade has seen a considerable spike in global carbon emissions.

Similarly, Paris Climate Agreement was the most looked upon international deal. Sadly, this too failed to meet its objectives as, by 2016, only 19% of the promised 100 BN dollars was released to the poor states.[39] Many of the experts have been of the view that the Paris Agreement is not ambitious enough to help bring the Earth's temperature at the optimum level. Even at the time of signing, it was not considered ambitious or effective enough to mitigate the environmental challenges.[40]

[38] Lindsay Maizland, "Global Climate Agreements: Successes and Failures," *Council on Foreign Relations*, November 17, 2021,
[39] Peter Yeung, "Paris Agreement has failed poor countries," *The Independent*, May 16, 2016,
[40] Yenug, 2016.

Moreover, activists and experts have remained skeptic of overambitious UN conference COP-26.[41] It has come under severe criticism as states couldn't meet the targets, they set for themselves. Here is an account of where things went wrong with many of the international regulatory bodies and conventions.

Basel Convention, too, has its own shortcomings. As for the transport of hazardous waste, the exporters have successfully found loopholes in the Basel Convention. The United States, one of the biggest producers of waste, did not to ratify it. Moreover, the shortcomings of the convention boil down to undue influence of the developed nations on the developing nations.[42]

Major deficiencies in the implementation of London Convention and London Protocol are to gain largescale participation, especially in the developing coastal nations. [43] Lodging national reports on dumping of waste into oceans are largely ignored and compromising the transparency and effectiveness of the Convention.

The problem greater than environmental degradation itself is mass oblivion, apathy, and above all complete denial of the existence of this problem as many of the sceptics deem claims about environmental deterioration as exaggeration and question the authenticity and severity of environmental degradation. Sceptics and conservatives are of the view that environmental challenges are unreal and unimportant, and this viewpoint has been a kind of countermovement to awareness on environmental issues.

This hazard is no creation of a single nation, nor can it be reversed by any single State. It's a common existential threat emanating largely from harmful human activities. It requires the world nations to spawn a collective resolve in the face of catastrophe and launch collaborative efforts to address it.

Indian Ocean is particularly vulnerable to climate change due to its importance for regional climate systems, economies, and ecosystems. Climate agreements emphasize the development and

[41] Maizland, 2021.
[42] Nikita Shukla, "How the Basel Convention has Harmed Developing Countries," *Earth.Org*, March 10, 2020,.
[43] Olav Schram Stokke, "Beyond Dumping? The Effectiveness of London Convention*," Yearbook on International Co-operation on Environment and Development 1998/99*, Routledge: 1998 f.

implementation of adaptation strategies. In the Indian Ocean region, adaptation measures are crucial for addressing the impacts of climate change, such as rising sea levels, changing rainfall patterns, and increased frequency of tropical cyclones. Adaptation efforts may include building resilient infrastructure, implementing sustainable land-use practices, and enhancing water resource management. Moreover, Climate agreements support the development and improvement of early warning systems for extreme weather events, including those that impact the Indian Ocean region. This is crucial for minimizing the risks associated with events such as cyclones and tsunamis.

6. Conclusion

UN report on "Global Assessment on Environmental Rule of Law" is one of its kind to discuss cooperative international efforts to protect and conserve environment for generations to come.[44] But alarmingly, despite presence of so many international protocols for environmental protection, implementation of environmental laws is absolutely missing. Despite environment protection organization has been multiplied in numbers but concrete outcome is not observed. International community is reluctant to surrender their sovereignty before any international organization to enforce global environmental laws which might hit their national interests. Parties of all agreements are in uncertainty that either other parties will follow the agreed protocol or not as they are not enforced bindings on the nations as recently US withdrew from Paris agreement. Above all, cost of implementing environmental laws is untenable which offers dimensions of non-compliance to the countries to save them from such financial burden.

UN Secretary-General Antonio Guterres- in UN Climate Change Conference-COP 26 says:

"I urge developed countries and emerging economies to build coalitions to create the financial and technological conditions to accelerate the decarbonization of the economy as well as the phase-out of coal." He further adds that "These coalitions are meant to support the large emitters that face more difficulties in the transition from grey to green. Let's have no illusions: if commitments fall short

[44] UNEP Report, "Environmental Rule of Law: First Global Report," *UN Environment Programme*, 24, January 2019,

by the end of this COP, countries must revisit their national climate plans and policies".

Capitalism has not given us the climate crisis alone but technological industrialism, and essential urge of socialism as well. Environmental damage under socialism has been as bad as or worse than under capitalism. Hegemonic struggle among interest groups with different level of available resources is creating turmoil. As, for economic revolution, carbon emission cannot be replaced which is directly contributing towards global warming and environmental threat. According to climate science denial is prevalent among rich and poor who place personal 'freedoms', small government, low taxes and national sovereignty before protection of the climate, despite the warnings of impending catastrophe. It reflects an entrenched worldview fixed not only on a particular understanding of the relationship of the individual to society but on the role of human beings on the planet. Human imprint on the global environment has now become so large and active that it rivals some of the great forces of nature in its impact on the functioning of the Earth system.

Recently conducted COP 28 in Nov-Dec 2023, exposits that there has been insufficient progress made in national climate plans. The conclusion of the first global stock take at COP 28 is seen as a turning point to scale up efforts in addressing climate change.[45] It is emphasized that immediate action is necessary to avoid the catastrophic consequences of climate change. The conference in Dubai is considered a pivotal moment for making strategic decisions and achieving meaningful outcomes to combat climate change. The United Arab Emirates, which presides over the talks, has also focused on the cycle of conflict and climate change, making COP 28 the first to address this connection. However, it's important to note that the president of COP 28 has dismissed demands for a phase-out of fossil fuels, claiming there is no scientific basis for such a move.

Recommendations

In light of the discussion following recommendations are proposed to cater deteriorating environmental conditions particularly in Indian Ocean region:

[45] UNFCC Report, "Fact sheet: Climate Change science – the status of Climate Change science today," *UNFCC*, 2011,

1. Water conservancy is important to be adopted to avoid water waste and runoff.
2. Optimized mass transit systems to make vehicles contributing less to reduce carbon footprint of petrol-based vehicles.
3. Development of economic cum environmental alliances for 'Safe Future of Planet'
4. Use of Non-toxic chemicals may be encouraged for domestic purposes to avoid contamination of water reservoirs.
5. "Reduce, Reuse and Recycle" had to conserve natural resources and landfills.
6. Periodical revisions in national policies are needed in every country to revisit national contribution to global environment protection.
7. Environment Protection and Awareness Campaigns (EPAC) have to be launched not only to make people aware of the importance of environment and gauging their responsibility. But EPACs at national and international level have to be launched to make responsible authorities realize of their responsibilities.
8. Regional environment protocols/ agreements have to be developed which must be region and climate specific as environmental factors and conditions vary.
9. Industries have to commit carbon neutrality by developing eco-friendly industrial units and production houses.
10. Marine Protected Areas had to be highlighted to make safe havens for marine life for rebuilding and restoring after trickling down impact of ocean pollution i.e., oil spilling and plastic pollution etc.
11. Technological advancements are needed in industries to minimize human footprint and solid industrial waste.
12. Impact evaluation studies may help to prioritize industrial and infrastructural projects.
13. From cultivation to storage to consumption, food industry is responsible for over 8% of global emissions. Developing environment-friendly processing and storage mechanisms and

consuming food in a sensible and balanced manner can ensure a reduction in global emission by a significant margin.

14. The non-proliferation regimes should be strengthened, and more safeguards should be developed to undermine the proliferation of nuclear weapons as well as the nuclear-propelled vessels in the Oceans.
15. New and innovative technological means should be employed to clean up oceanic pollution. For example, semi-autonomous systems can dive deeper and travel farther for exploring and clean the ocean from pollutants.
16. Governments should take strict measures for eradicating illegal, unreported and unregulated fishing (IUUF). The use of plastic nets and other harmful fishery tools not only contaminate the ocean but also threaten the natural marine lifecycle.

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Realization of Vessel Productivity Enhancement via Comparative Analysis of Liner Services: A case of Qasim International Container Terminal (QICT) DP World, Karachi

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Abstract

The landscape of the shipping industry is constantly evolving. The key aspect point among numerous issues is the efficiency of container loading and offloading on the quayside. This research aims to analyze the performance of Qasim International Container Terminal (QICT) DP World Karachi, Pakistan via Key Performance Indicators (KPIs) evaluation, based on data gathered fqictfrom QICT, and to find the critical factors affecting the overall productivity of QICT. Comparative analysis of liner services of Maersk between Mawingu (MWG) Express and Jade Express was performed via KPI's data collection from the Operation Department of QICT. This research concludes that vessel Productivity is reliant upon several factors. The most significant among all is the competence of the operator, number of quay cranes utilized at the terminal, number of transfer vehicles, berth allocation, and yard utilization. The study recommends to the terminal regarding optimum number of crane allocation and appropriate yard management to enhance the productivity of the JADE liner service via proactive maintenance of the ship-to-shore cranes.

1. INTRODUCTION

Containerization has led to the evolution of the shipping industry, resultantly, the size and capacity of the ships increased as

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shipping companies get additional benefits on the economies of scale[1].

Figure 1. Shows the present leanings in the shipping industry that pressurizes ports to increase productivity. (Source: UNCTAD 2017)

The growing size of container vessels continually injecting altering port productivity and intensifies competition among container terminals globally, both on a national and international scale[2]. However, financial pointers are concerned with costs expended and profits generated by a terminal through its operations. Operational factors that influence these indicators include metrices: the number of containers moves per hour by quay cranes, container dwell time, the average turnaround time of vessels, and the productivity of operators.[3]. An improved understanding of variables that institute delays of cargo in container terminals and directing major issues are important to enhance the productivity of a container terminal[4].

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Qasim International Container Terminal (QICT), managed by DP World Dubai has an isolated truck holding area for all import and export vehicles to accelerate fast truck turnaround. To build the QICT, 03 existing multipurpose berths of six hundred meters in length were transformed into 02 berths container terminals for USD 100 million. Operational since August 1997, the terminal spans 240,000 square meters. Designed to handle 0.6 million twenty equivalent units (TEUs) per year, the terminal can handle vessels up to three hundred and five meters in length (DP World, n.d)[5].

Figure 2. Qasim International Container Terminal (QICT) (Source: DP World, "Qasim International Container Terminal (QICT)," https://www.dpworld.com/en/karachi (Accessed [10-10-2023])

A serious concern of port logistics at container terminal is the dwell time as the reduced dwell time enables the port to perform more efficient. However, non-reliable dwell time is leads to time and efficiency problems. Terminal operators face challenges in optimizing their operations, particularly in minimizing unproductive and costly container handling within the terminal[6]. Despite all the achievements in improving container terminal performance in terms of equipment and container stacking systems (CSS), terminal operators are still facing several challenges such as the Loading and unloading process at Container Terminals and Container Yards that cause bottlenecks in

[5] DP World. "About DP World Karachi." Accessed [10/10/2023]. https://www.dpworld.com/en/karachi/about-us/about-dpw-karachi.

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container utilization [7]. The scientific planning and scheduling in process of loading, unloading, collecting, and carrying container operations directly affect the production efficiency of the container terminal. This implies a need for port authorities to implement more robust strategies to maintain efficient and competitive port services[8]. The following flowchart depicts the service process flow chart of ship loading / unloading system:

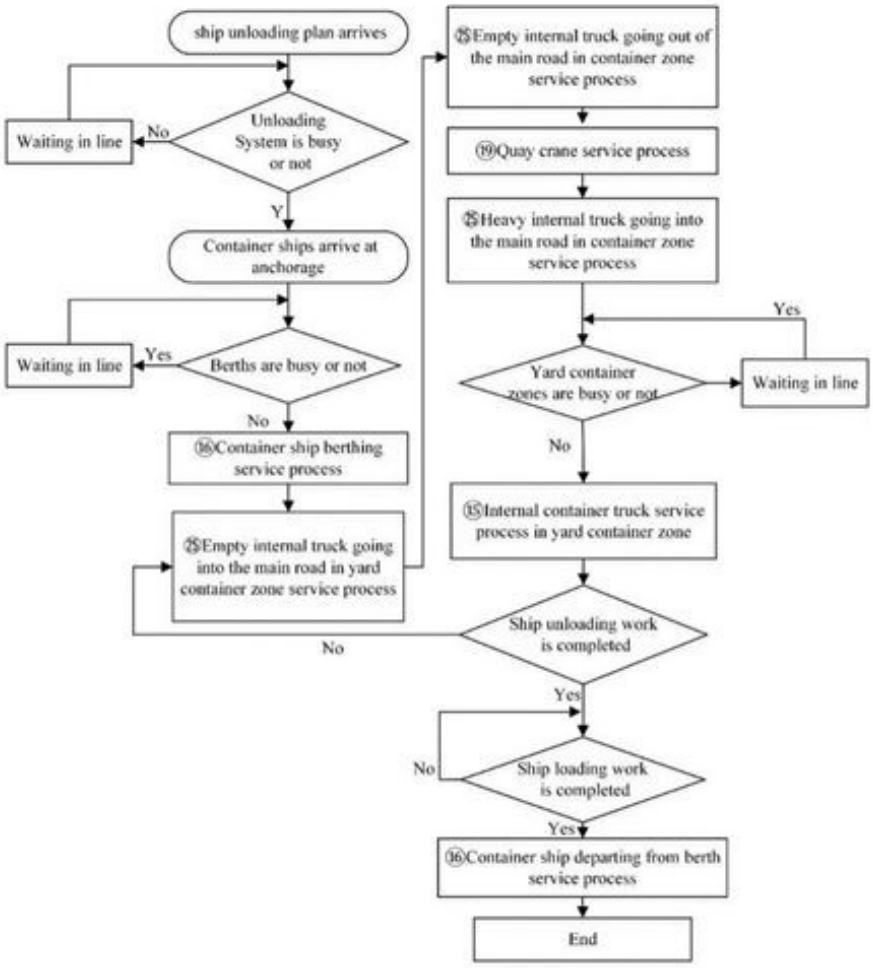

Figure *3.* Service process flow chart of ship loading / unloading system (source : https://www.researchgate.net/figure/Service-process-flow-chart-of-ship-loading-unloading-system_fig4_356390330)

[7] Mazloumi, Mehdi, and Edwin van Hassel. "Improvement of Container Terminal Productivity with Knowledge about Future Transport Modes: A Theoretical Agent-Based Modelling Approach." Sustainability 13, no. 17 (2021): 9702.

[8] Zohaib, H. S., & Zaidi, S. S. Z. (2022). Antecedents of Maritime Supply Chain Resilience Affecting Supply Chain Performance–An Empirical Study Based on Pharmaceutical Industry. GMJACS, 12(2), 82-103.

The potential vessel productivity is much higher than the actual resulting productivity of one service MWG is consistently low and there are numerous causes behind it. Therefore, DP World Karachi would like to increase its vessel productivity for MWG Service by making key decisions on controllable variables, considering the possibility of any process improvement associated with the steps involved, and performing gap analysis with another service with consistently higher GMPH. Therefore, it leads to the following research questions:

RQ 1. What are the factors that affect efficient container handling operations?

RQ 2. Are determined factors applicable to QICT?

RQ3: What are the potential causes that are currently limiting the productivity of MWG service?

RQ 3. Can improvements in the efficiency of container handling operations be made at QICT?

RQ 4. If improvements are made, can these achieve a increased GMPH target on the MWG service?

The objective of this research is to identify and mathematically realize the gaps in the operability of QICT and further suggest ways to enhance/improve decision-making on controllable KPIs for enhancing productivity. Moreover, the study is focused on observing the present status of Qasim International Container Terminal operations and ship handling operations at QICT. Considering that relevant to Pakistan, maritime sector literature is scarce[9]. This area needs attention because terminal and ship handling operations are significant for terminal operations. As the containerized trade volume is increasing annually, the same traditional method of operating is not compatible with increasing and variating terminal demands. This impedes the true potential of productivity of the terminal. The customary method utilized to gauge the productivity of a container terminal employs the number of containers moves hourly handled by a quay crane or STS crane[10]. The productivity measures for the research include:

[9] Ahmed, Azhar. "Role of Maritime Strategy in National Security-a case study of Gawadar." PhD diss., National Defence University, Islamabad, 2014.

[10] Review of Maritime Transport 2013 - UNCTAD

1) The total time of a vessel at berth
2) Service, TEUs per hectare
3) Quay cranes productivity
4) Operator productivity
5) The number of vessels visiting under both services at QICT.

Terminal productivity is evaluated from different perceptions such as efficacy, comparative and mechanical productivity, and cost-effectiveness against the optimal throughput [11]. One method to measure the productivity of major container terminals is by examining the relationship between the percentage of utilization and optimal throughput of a single variable. However, it disregards the exchange and association between the factors of productivity [12]. Moreover, specifies the correlation of high quay output with the increased number of ships awaiting berth, which causes the bottleneck.

The figure below exhibits the container terminal and the variability of operability, which has a significant impact on the productivity and efficiency of a container terminal. The berths handle the arrival of ships to the terminal, including pilotage services, tug assistance on request of the ships, and mooring activities. Cargo is transshipped from the terminal to the ship and from the ship to the terminal in the apron area. The temporary storage of cargo in terminal stacking areas in anticipation of further transportation. Connection to the hinterland is by road or rail (i.e., gated).

[11] Erkyehun, Eyerusalem. "Determinant of Dry port operational performance of Ethiopian shipping and logistic service enterprise (eslse): the case Modjo And kality dry port branchs." PHD diss., St. Mary's university, 2021.

[12] Alhameedi, Mohamed Ebrahim AS, Abud Jamal Said, and Tri Wahyunita Mudjiono. "Performance evaluation and solutions for port congestion focused on the container terminal: a case study of Khalifa bin Salman Port (KBSP) Kingdom of Bahrain." (2018).

2. LITERATURE REVIEW

Figure 4. A Schematic Container terminal layout (From Process Mining for port container terminals: The state of the art and issues, 2018)

Productivity is defined as the efficient use of resources (inputs) in the production of goods and/or services (output)[13]. However, productivity of container terminals may be measured in two different ways in the shipping industry. Vessel operations are the first category, which includes the loading and discharge of containers onto and from vessels. Container transfer between outside vehicles during receiving and delivery activities is the other one[14].

Port performance measurement is a crucial input for nationally and internationally port planning and operations in the current business market. It is also a strong management tool for port operators. It has been stated that earlier, many methods of evaluating the operation of ports have included estimating cargo-handling productivity at berth[15]. The cargo transfer across a quay between ship

[13] Sumanth, David J. "Productivity Engineering and Management: Productivity Measurement, Eveluation, Planning, and Improvement in Manufacturing and Service Organizations." (1984).

[14] Kim, Kap Hwan, Keung Mo Lee, and Hark Hwang. "Sequencing delivery and receiving operations for yard cranes in port container terminals." International Journal of Production Economics 84, no. 3 (2003): 283-292.

[15] Helen B. Bendall and A. F. Stent, “On Measuring Cargo Handling Productivity,” Maritime Policy & Management 14, no. 4 (1987): 337–43, https://doi.org/10.1080/03088838700000046.

and shore essentially determines the vessel's productivity and is essential to its competitive position because a container shipping line is one of a container port's most important clients. The gantry crane is the most crucial piece of equipment in the entire process (the quay crane transfer operation)[16]. It has been argued that the container terminal's production relies on the optimum use of labor, land, and equipment. Therefore, terminal production is measured through quantifying efficiency in the utilization of these three resources[17].

2.1 Vessel Productivity

Vessel Productivity or productivity, in general, is an overview of the number and quality of work performed while taking resource usage into account. Productivity (P) is defined as the average of the gross moves per hour (GMPH) for each call recorded last year. Gross moves per hour for a single vessel call is defined as the total container moves (load, offload, and repositioning) divided by the number of hours for which the vessel is at berth. However, productivity is defined as the efficient use of resources (inputs) in the production of goods and/or services (output)[18]. While it has been stated that the productivity of container terminals may be measured in two different ways in the shipping industry. Vessel operations are the first category, which includes the loading and discharge of containers onto and from vessels. Container transfer between outside vehicles during receiving and delivery activities is the other one[19].

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[16] Bendall, Helen B., and A. F. Stent. "On measuring cargo handling productivity." Maritime Policy and Management 14, no. 4 (1987): 337-343.

[17] Dowd, Thomas J., and Thomas M. Leschine. "Container terminal productivity: a perspective." Maritime Policy & Management 17, no. 2 (1990): 107-112.

[18] Sumanth, David J. "Productivity Engineering and Management: Productivity Measurement, Evaluation, Planning, and Improvement in Manufacturing and Service Organizations." (1984).

[19] Kim, Kap Hwan, Keung Mo Lee, and Hark Hwang. "Sequencing delivery and receiving operations for yard cranes in port container terminals." International Journal of Production Economics 84, no. 3 (2003): 283-292.

productivity at berth[20]. The cargo transfer across a quay between ship and shore essentially determines the vessel's productivity and is essential to its competitive position because a container shipping line is one of a container port's most important clients. The gantry crane is the most crucial piece of equipment in the entire process (the quay crane transfer operation)[21]. It has been argued that the container terminal's production relies on the optimum use of labor, land, and equipment. Therefore, terminal production is measured through quantifying efficiency in the utilization of these three resources[22].

Many factors may have an impact on the productivity of the vessel but there are five factors or variables that are major or rather mandatory to determine the vessel productivity and the variables are:

1. Berth/Wharf#
2. Yard Utilization
3. Number of Cranes Used
4. Vessel Type
5. STS Operators' Performance

3. METHODOLOGY

The research was conducted in an applied approach where a quantitative method is used for analyzing data on key variables driving the productivity of a container terminal at QICT. The site of research was Qasim International Container Terminal (QICT). This site was selected due to its huge volume of containerized trade and the significance of the multi-purpose container terminal. The research methodology employed in this study aimed to comprehensively evaluate the productivity of Qasim International Container Terminal (QICT) in the maritime sector. To achieve this objective, a multi-faceted approach was utilized. The initial step involved the collection of extensive data on terminal operations, vessel movements, and various performance indicators over a one-year period. The data was collected from the operations department of the QICT.

[20] Bendall, Helen B., and A. F. Stent. "On measuring cargo handling productivity." Maritime Policy and Management 14, no. 4 (1987): 337-343.
[21] ibid
[22] Dowd, Thomas J., and Thomas M. Leschine. "Container terminal productivity: a perspective." Maritime Policy & Management 17, no. 2 (1990): 107-112.

The data formed the foundation for quantitative analysis and the identification of key patterns and trends. Subsequently, detailed statistical analyses and comparative assessments were conducted to gauge the efficiency of QICT in different aspects, including berth allocation, crane performance, and service productivity. Specifically, parameters under investigation were productivity, berth allocation, yard utilization, number of cranes utilized, and operator performance data were collected to comparatively analyze the productivity of both of the services. Moreover, data accessibility was limited as the operations department provided only a restricted data set due to confidentiality concerns.

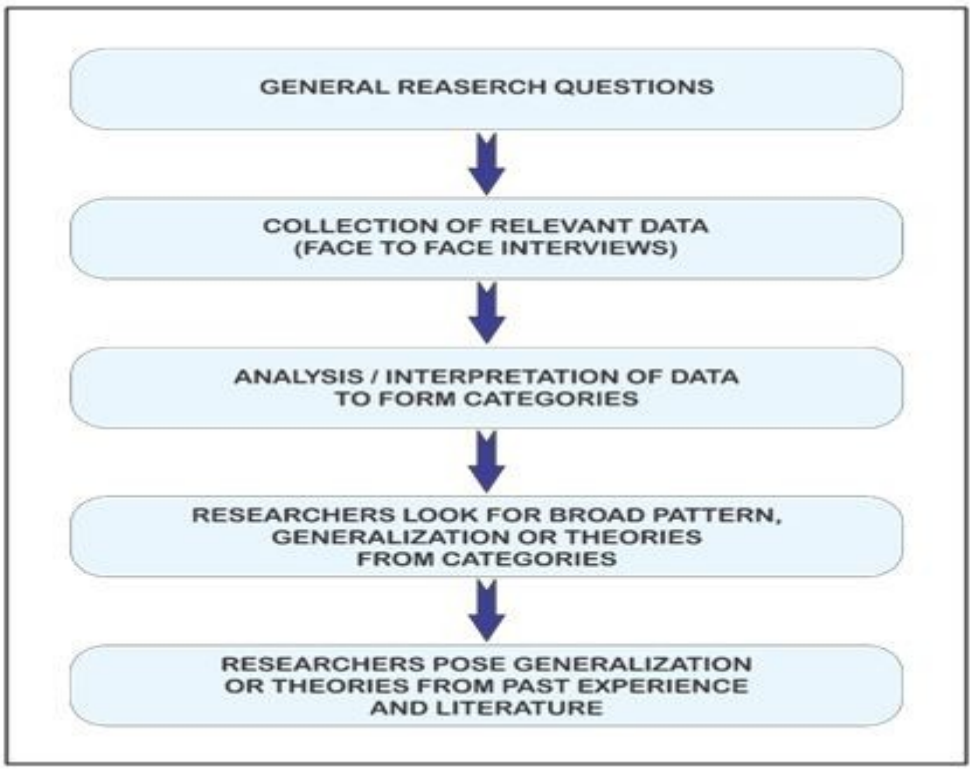


Figure 5. Phase I general research process[23].

4. DATA ANALYSIS

Most importantly used KPIs include Vessel traffic, and the number of vessels entering/ leaving a container terminal facility over a

[23] Bell, Emma, and Alan Bryman. "The ethics of management research: an exploratory content analysis." British journal of management 18, no. 1 (2007): 63-77. Creswell, John W. "Mapping the field of mixed methods research." Journal of mixed methods research 3, no. 2 (2009): 95-108.

period which also determines the local effectiveness of a container terminal. An important element in determining the total number of containers (TEUs) managed within a specific period is what we refer to as productivity measurement which assesses the efficiency and effectiveness of various processes involved in container handling at ports or terminals. The assessment of the vessel productivity of a container terminal principally quay cranes utilized in containers handling to/from a vessel is termed operative productivity[24].

4.1 Berth / Wharf Number

The primary performance indicators of a container port are considered berth allocation and vessel storage planning[25]. One of the main planning issues for container port operations is the Berth Allocation Problem. Every vessel anticipated to be served within a certain perspective of planning is allotted a berthing spot and a time of berthing[26].

It has been realized that the MWG service is having greater productivity when the vessel is being berthed at Wharf number 07 than at wharf number 05 and 06. This is due to the distance of the stacking yard designated for MWG service being much nearer from wharf number 07 as compared to that of wharf number 05 and 06. During the berth planning, it is recommended that the MWG service should be allocated wharf number 07 if available to enhance the productivity of the MWG service.

[24] Chen, Longbiao, Daqing Zhang, Xiaojuan Ma, Leye Wang, Shijian Li, Zhaohui Wu, and Gang Pan. "Container port performance measurement and comparison leveraging ship GPS traces and maritime open data." IEEE Transactions on Intelligent Transportation Systems 17, no. 5 (2015): 1227-1242.

[25] Vis, Iris FA, and Roel G. van Anholt. "Performance analysis of berth configurations at container terminals." OR spectrum 32, no. 3 (2010): 453-476.

[26] Steenken, Dirk, Stefan Voß, and Robert Stahlbock. "Container terminal operation and operations research-a classification and literature review." OR spectrum 26, no. 1 (2004): 3-49.

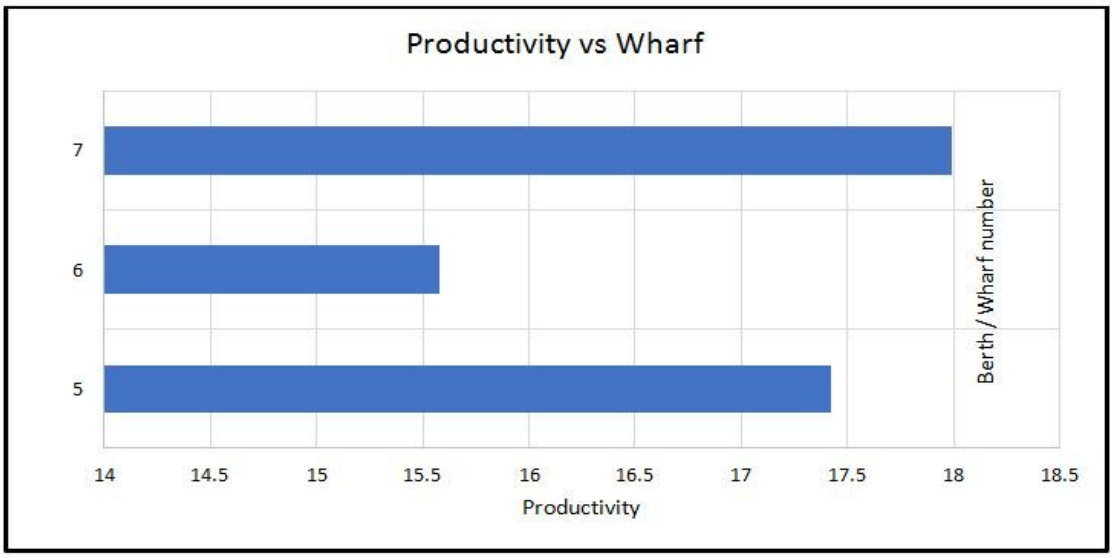


Figure 6. Shows productivity concerning the allocated berth/wharf number.

4.2 Yard Utilization

It has been claimed that the terminal's vessel productivity is also affected by the workload of transport means within the yard. It could be determined by the distance between the areas for import and export containers[27]. For a vessel near these yard areas, a preferred berthing site is typically stated. The horizontal transport's load rises if the actual berthing position chosen differs from the desired position. Increasing ITVs usage can help to mitigate this effect to some extent.

[27] Meisel, Frank, and Christian Bierwirth. "Heuristics for the integration of crane productivity in the berth allocation problem." Transportation Research Part E: Logistics and Transportation Review 45, no. 1 (2009): 196-209.

Below mentioned data shows the relationship between productivity and yard utilization during the vessel operations (From QICT records)

R-Square (coefficient of Determination = 0.153)

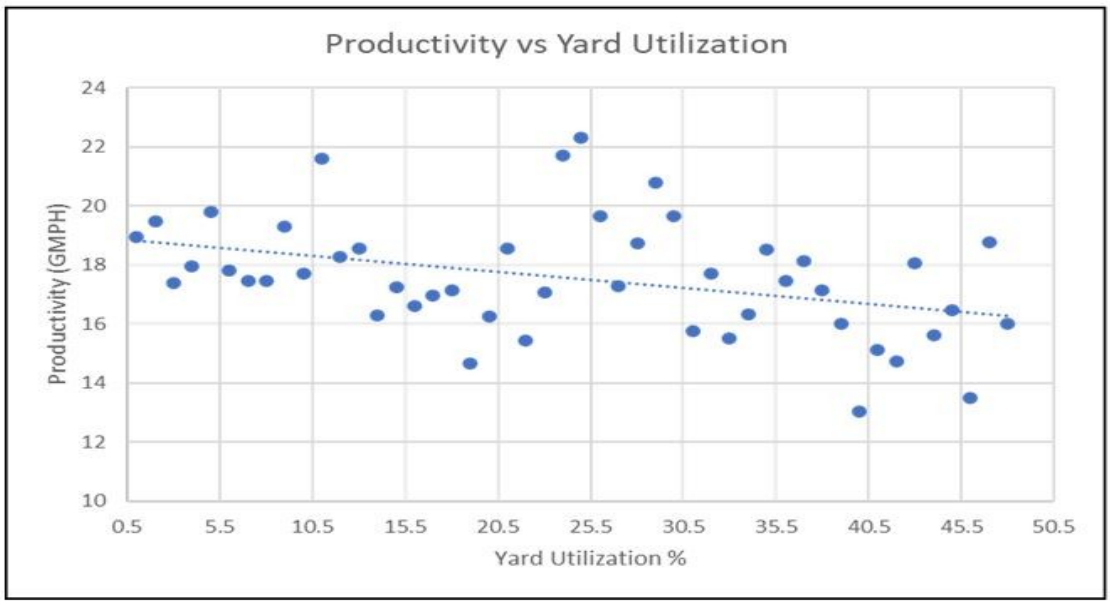


Figure 7. *A relationship between Productivity (GMPH) and Yard Utilization in the progress of vessel operations.*

The Yard utilization graph interpretations that the increases in yard utilization led to a decrease in overall vessel productivity. The berth/wharf allocated to the vessel affects the yard utilization in such a manner that if the stacking yard of that service is on more distance from the berth/wharf then it will involve more yard utilization and lead to lower productivity. Therefore, the vessel must be assigned a berth/wharf that is at a short distance from the stacking area of that respective service to have enhanced productivity.

4.3 Number of Cranes Used

At a container terminal, quay space and quay cranes (QCs) are valuable components. Generally, the Quay Crane Assignment Problem (QCAP) emerges when multiple vessels moor at the quay at just about the same timeframe. The minimal number (agreed upon by the vessel operator and the operator of the Container Terminal) and the technically permissible maximum number are sometimes used to limit the number of QCs serving a vessel concurrently. The QC-to-Vessel assignment may alter as a vessel is handled.

Below mentioned data shows productivity to berth/wharf number of the vessels being berthed during the vessel operations (From QICT records)

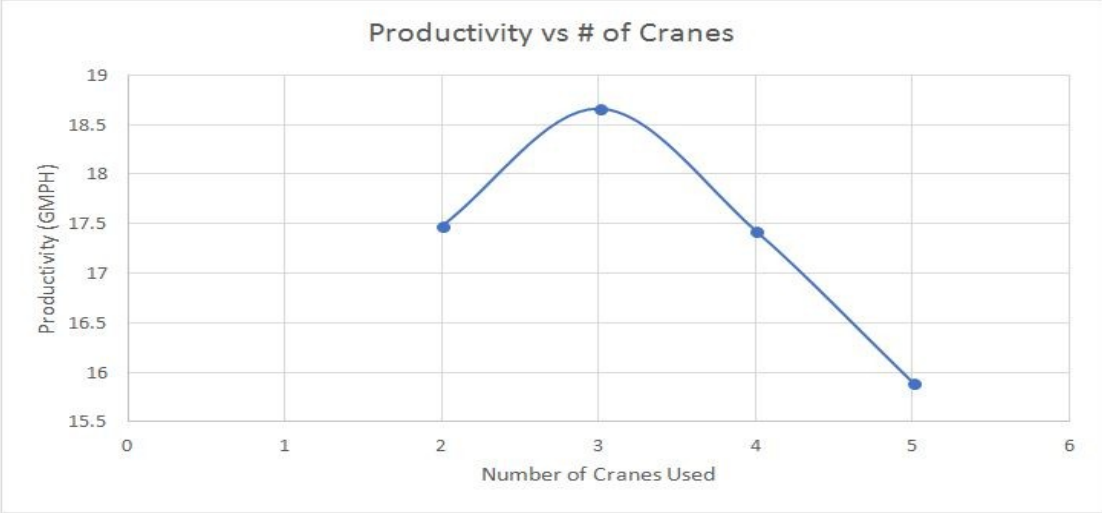


Figure 8. Relationship between Productivity & Number of Quay Cranes used during vessel operations at QICT.

The number of cranes used affects productivity in such a different manner than if there are a smaller number of cranes used then it will decrease productivity because of more time taken to complete the operation & a greater number of bays covered by a single crane. On the other hand, an increased no of cranes will also minimize productivity as it will cause congestion of ITVs in the Terminal. Modeling and simulation tools/systems must be introduced for optimization of the number of cranes used with respect to the vessel size. This system must be capable of aiding the terminal planners to use exactly those numbers of cranes for efficient operations according to the size of the vessel.

4.4 Vessel Type

The vessel's productivity is significantly affected by its structural design, especially when the placement of containers and superstructure obstructs crane operations during bay changes. When the superstructure is positioned at a higher altitude, it forces the crane to raise its boom, leading to delays, increased time consumption, and decreased overall productivity.

4.5 STS Operators' Performance

Container Terminal operators constantly put effort into saving time and focusing on restructuring loading and offloading procedures. Turnaround time is a crucial one and a large portion of the container terminal turnaround time depends on loading and offloading operations[28]. Enhancing container handling operations productivity is dependent largely on the STS crane operator's efficiency. The Crane operator's performance changes the efficiency of the whole container terminal. Productivity of a lift of a container for loading, offloading, or relocating purposes[29]

Crane Operator Performance = Gross moves/ Total hours expanded

Operators should aim to minimize waiting times by optimizing crane allocation and intensities. Comprehensive operator training is essential to ensure all operators have the required skills to perform their tasks efficiently. Thus, container terminals should implement effective training programs to maximize operator productivity. *The data provided displays shift-wise productivity for each crane operator, determined by the number of moves and their total working hours during April 2022*

[28] Cao, Jin Xin, Der-Horng Lee, Jiang Hang Chen, and Qixin Shi. "The integrated yard truck and yard crane scheduling problem: Benders' decomposition-based methods." Transportation Research Part E: Logistics and Transportation Review 46, no. 3 (2010): 344-353.

29 Bojan Beškovnik, "Measuring and Increasing the Productivity Model on Maritime Container Terminals," Pomorstvo/Journal of Maritime Studies 22, no. 2 (2008)

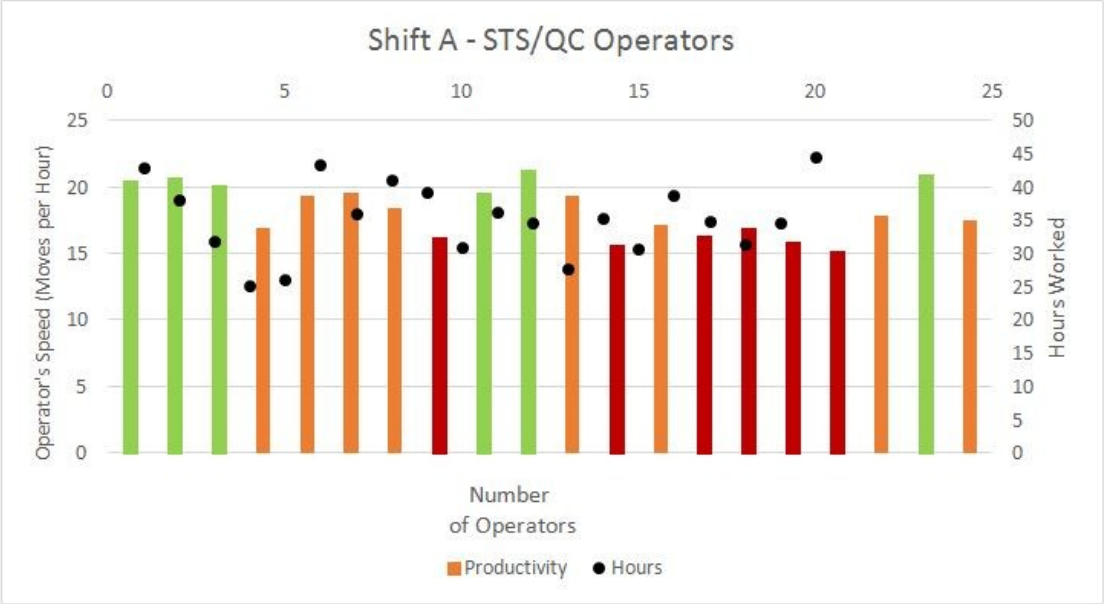


Figure 9. Shows the productivity of Shift 'A' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

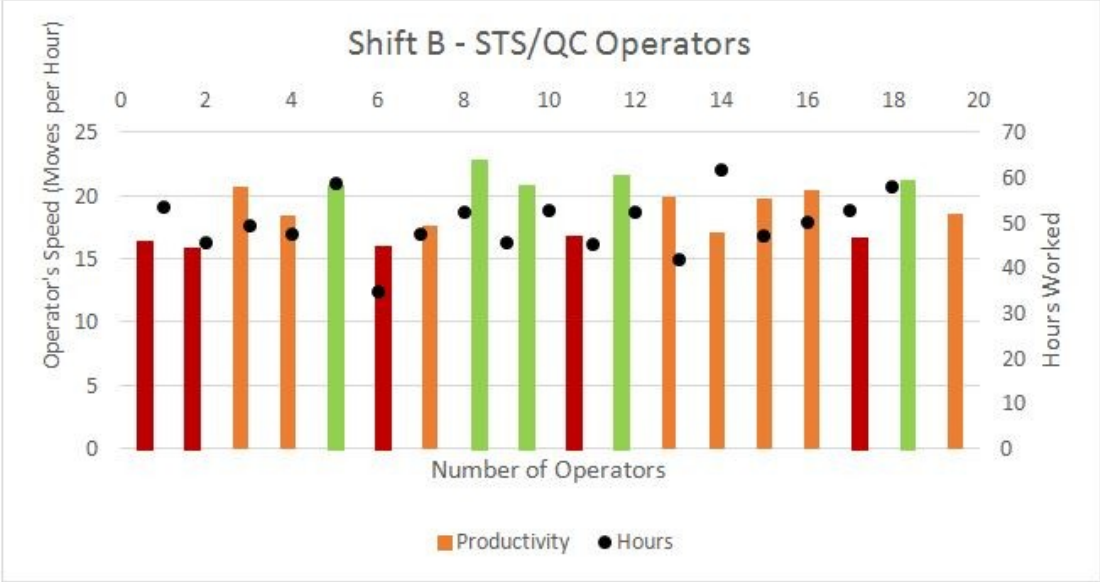


Figure 10. Shows the productivity of Shift 'B' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

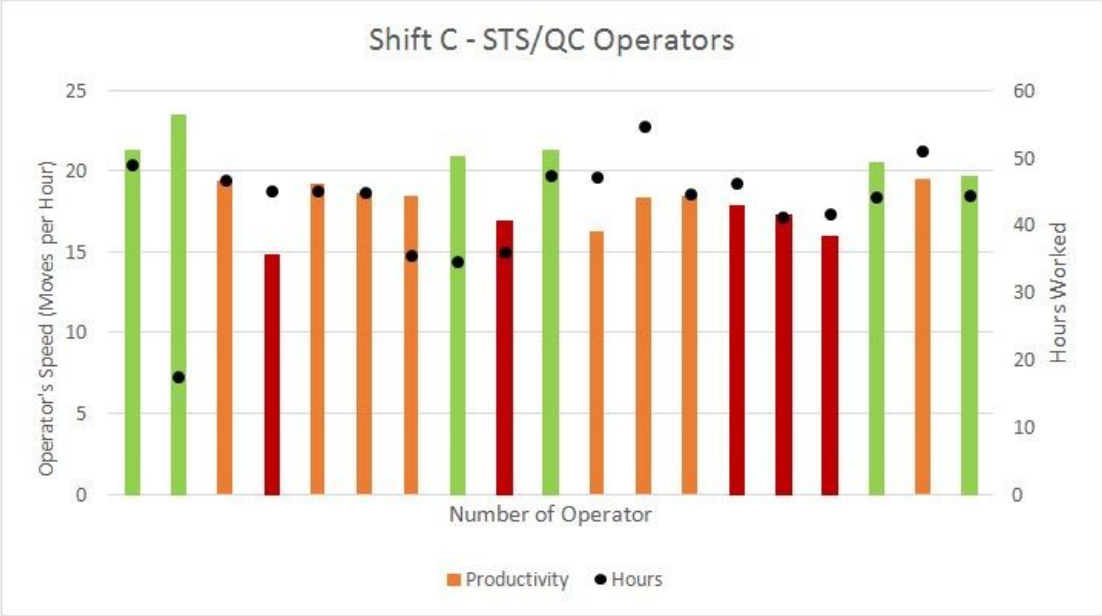


Figure 11. Shows the productivity of Shift 'C' STS Crane Operators in terms of moves per hour and total hours expanded for one month at QICT.

The provided figures demonstrate a range in productivity among 57 Crane Operators at QICT, varying from 14.87 to 23.46 Moves per hour. Operator 2's productivity is notably 58% higher than the lowest-performing Operator 4, indicating a significant skill gap. To address this gap, QICT management should consider incentivizing low-performing operators to improve and implement a training program using STS simulators. Ensuring transparency in operator rotation is vital to offer every operator an equal chance for improvement, ultimately enhancing overall productivity.

The data highlights the suboptimal usage of operators. Each operator's productivity varies significantly from the others. To enhance service productivity, it's necessary to optimize operator usage by shifting from random shift patterns to those aligned with the terminal's requirements.

5. COMPARATIVE ANALYSIS OF LINER SERVICES (MWG vs JADE)

The comparative analysis of MWG and JADE services of Maersk Line is done in terms of their Vessel Traffic, throughput, Gross

Moves Per Hour (GMPH), and average vessel turnaround time. MWG (Mawingo) service touches the ports of Mombasa (Kenya), Salalah (Oman), Port Qasim (Pakistan), Mundra (India), Pipavav (India) and Jawaharlal Nehru (India).

5.1 VESSEL TRAFFIC

Vessel traffic data was acquired for the past fourteen months (Jan 21 – Feb 22). The figure below shows month-wise vessel traffic arriving at QICT.

vessel traffic records for MWG and JADE Services, detailing the number of arrivals and departures, along with the actual arrival and departure times at QICT. The data spans from January 2021 to February 2022

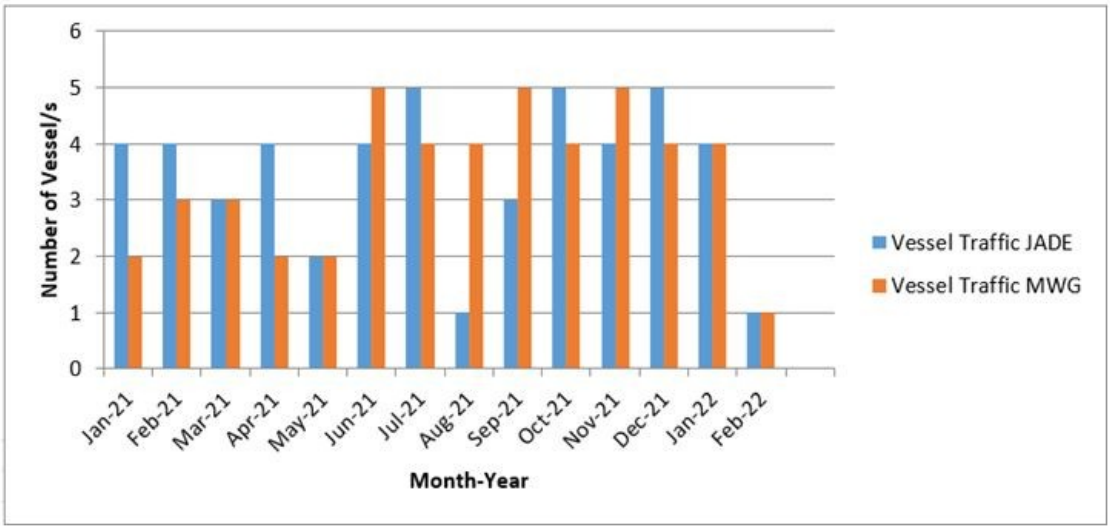


Figure 12. Vessel Traffic of JADE & MWG Services arriving at QICT (Jan 21 – Feb 22).

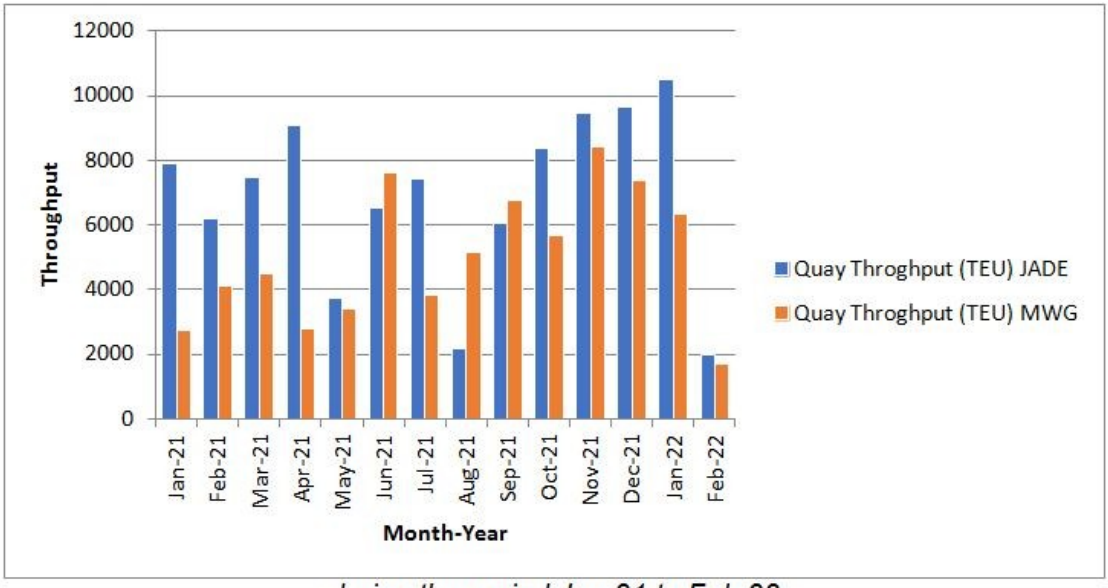
The data reveals that QICT had 48 vessels arrive for JADE Service and 49 for MWG Service. Notably, 5 vessels visited in July, October, and December 2021, marking the highest number of port calls for JADE Service. Similarly, for MWG Service, the highest number of vessels visiting was also 5 in June, September, and November 2021. On average, approximately 3.5 vessels visited per month for JADE Service, and 3.4 for MWG Service. This suggests a similar number of vessels visiting for each service. A comparative

analysis of JADE and MWG services is crucial to identify the factors contributing to MWG's lower productivity compared to its capacity.

5.2 QICT THROUGHPUT (JAN 21 TO FEB 22)

Quay Throughput (TEUs) represents the quantity of TEUs moved over the quay wall for Mainliners, Feeders, and Barges, excluding Hatch covers, lashing bins, and convenience re-stows. Data on the throughput of JADE and MWG Services was gathered from Qasim International Container Terminal (QICT). The table below displays the combined throughput for both services. The lowest throughput for both services occurred in February 2022, attributed to fewer vessel visits at the container terminal. In contrast, the highest throughput for JADE Service was 10,515.75 TEUs in January 2022, and for MWG Service, it reached 9,474.25 TEUs in November 2021

Below mentioned data shows the QICT quay throughput of JADE & MWG Services during the period Jan 21 to Feb 22



during the period Jan 21 to Feb 22

Figure 13. Container Terminal Throughput of JADE & MWG Services.

Figure depicts the throughput trend from January 2021 to February 2022 for JADE and MWG Services. JADE Service generally maintained higher throughput compared to MWG Service, except for three months (June 2021, August 2021, and September 2021). In

January 2021, the throughput of JADE Service was 7,908.25 TEUs, which was 191% higher than MWG Service's 2,717 TEUs. To enhance operational efficiency, it's suggested to classify liner services into A, B, and C categories based on their throughput, with first-class services receiving priority in terms of equipment availability and early berthing due to their significant contribution to QICT's revenue. Collaboration with MWG service agents is also recommended to address inconsistent throughput in this liner service.

5.3 GROSS MOVES PER HOUR (GMPH)

Gross Moves Per Hour (GMPH) indicates the number of containers moved by a crane and it is the customary measurement to calculate productivity for handling containers at container terminals[30].

the average gross moves per hour, calculated from loading, offloading moves, and crane hours for the JADE and MWG Services (from Jan 21 to Feb 22)

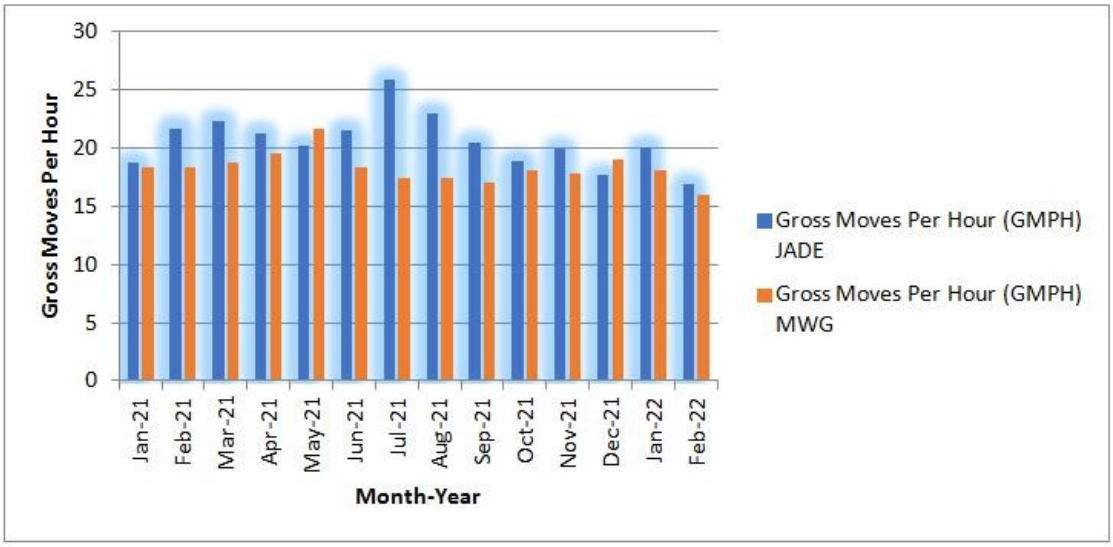


Figure 14. Shows Average Gross Moves Per Hour for the JADE & MWG Services (Jan 21 – Feb 22).

Gross Moves Per Hour for JADE Service at QICT varied from 16.93 to 25.86 and remained between 15.93 to 21.7 for MWG Service. It has been realized that the same quay crane operators and quay

[30] Global Port Pricing Comparator Study 2015. (n.d.). Ports Regulator of South Africa. https://portsregulator.org/global-port-pricing-comparator-study-2015/

cranes were utilized for handling containers of both services, however, Gross Moves Per Hour for JADE Service has remained higher throughout the year than MWG Service except for May & Dec 21. The above graphical analysis indicates that the arrangement of containers on container terminal i.e., t the yard needs to be reviewed/ reorganized to achieve increased GMPH for MWG Service. Intense collaboration is needed with MWG service's agent to show up their plans regarding port calls at QICT to have good productive results.

5.4 AVERAGE TURNAROUND TIME

Turnaround time is the complete time ship spends at a terminal from ATA (Actual Time of Arrival) until ATD (Actual Time of Departure)[31]. Usually, a vessel is not making money during her stay at the terminal but pays for the terminal services, therefore, shipping companies tend to limit the turnaround time as minimum as practicable. Pakistani ports have one of the highest port dues charges, therefore, vessels must be attended to with the greatest proficiency to minimize port stay leading to the omission of extra port dues.

Below mentioned data shows the average turnaround time of a vessel considering the total berth time for JADE & MWG Services from Jan 21 to Feb 22 (From QICT records)

Figure 15. Demonstrates month-wise average turnaround time (in Hours) of JADE & MWG Services (Jan 21 – Feb 22).

[31] Sánchez, Ricardo J., Jan Hoffmann, Alejandro Micco, Georgina V. Pizzolitto, Martin Sgut, and Gordon Wilmsmeier. "Port efficiency and international trade: port efficiency as a determinant of maritime transport costs." Maritime economics & logistics 5, no. 2 (2003): 199-218.

Average turnaround times for JADE Service varied from 29.29 hours in January 2022 to 21.24 hours in June 2021. In contrast, MWG Service saw a range from 38.33 hours in February 2022 to 19.77 hours in October 2021. MWG Service displayed a steady decline in turnaround times from 32.33 hours in January 2021 over six months until July 2021. In comparison, JADE Service started at 25.87 hours in January 2021 and remained steady for five months until May 2021.

JADE Service generally had a longer average turnaround time than MWG Service due to handling a larger volume of containers, necessitating extended vessel stays. However, opportunities for improvement exist, including reducing equipment and quay crane failures that can prolong vessel stays. Operational enhancements such as increasing the number of cranes, minimizing shift change delays, and improving crane operator efficiency can help achieve this. UNCTAD suggests that the average vessel turnaround time is 33 hours, with most vessels aiming to stay within port limits for less than a day due to the 24-hour rate for port dues.

5.5 SHIP TO SHORE (STS) CRANES PRODUCTIVITY DURING MAR 22

An STS crane is purposefully designed for handling container Ships. These days, the biggest STS cranes can handle more than 120 tons and are capable of outreaching more than 70 meters and a lifting elevation of up to 50 meters[32]. Numerous STS cranes handle containers concurrently on a single ship. Operating side by side requires enough space to function freely. As the STS cranes are in direct contact with the ships, therefore, the productivity of ship-to-shore actions is a very precarious phase at any container terminal. While analyzing the productivity of STS crane operations, the most important standard moves per hour (mph). It denotes the number of

[32] S. (n.d.). STS Gantry Crane. Https://Www.Weihuagantrycrane.Com/Product/STS-Gantry-Crane.Html. https://www.weihuagantrycrane.com/product/STS-Gantry-Crane.html

containers or TEUs relocated per hour. The productivity of an STS crane is gauged by the said method[33].

the productivity of every STS crane in terms of moves per hour during the day & night shifts

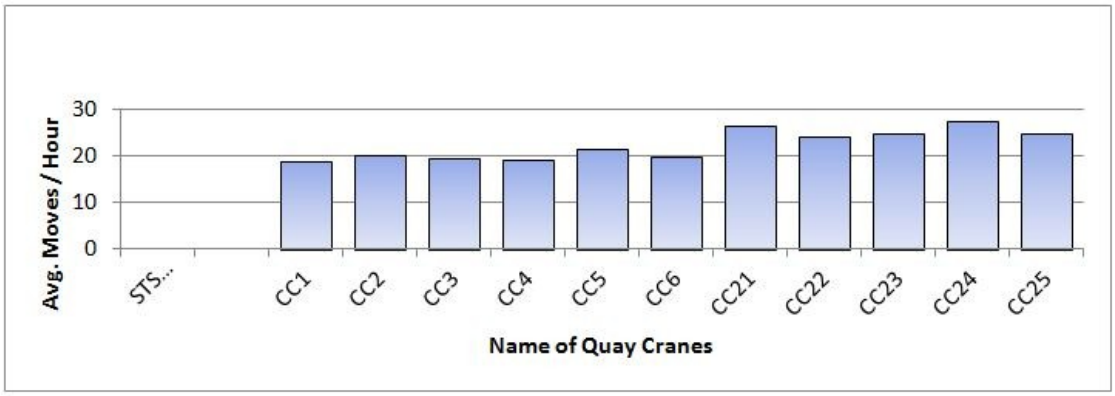


Figure 16. Shows the average moves of STS cranes per hour during Mar 22.

QICT operates 11 STS Cranes, with varying performance in March 2022. STS Crane CC24 demonstrated the highest productivity with 27.46 moves per hour, while CC1 performed at 18.80 moves per hour, the lowest among all. The older STS Cranes (CC1 to CC6) displayed lower productivity due to machinery failures and wear and tear. To improve performance, proactive maintenance is necessary to prevent sudden breakdowns. The engineering team should analyze patterns of breakdowns and failures. Therefore, increasing resource allocation to reduce failures in low-performing STS Cranes is essential for enhancing overall productivity at QICT.

6.1 DISCUSSION AND CONCLUSION

Qasim International Container Terminal (QICT) intends to offer supreme services and accommodates all shipping liners. The QICT is situated far away from the crowded city of Karachi, thus yielding a faster turnaround of the import and export freights. An analysis of the QICT productivity was undertaken with results. Now, this section is aimed at drawing substantial deductions and recommendations from the study.

[33] Koivula, Jarno. "Modelling and simulation of ship-to-shore operations for productivity analysis." Master's thesis, 2019.

Allocation of berth to a vessel is always a challenging task. As the actual time of arrival of vessels is not constant and always dependent on mechanical operational machinery and most importantly suitability of weather at sea. Also, when there are multiple vessels awaiting berth then the decision becomes more difficult. As QICT is handling more than 50 percent of the imports/ exports of Pakistan, therefore, a more efficient berth planning is required to increase the berth occupancy rate up to the maximum level possible to increase the productivity of the container terminal. An effective berth planning is also mandatory on occasion when a bigger vessel arrives after already awaiting a relatively smaller vessel in the harbor for productivity purposes. The objective of the research was to evaluate the efficiency of QICT to increase the productivity of the terminal, conduct analyses of the Key Performance Indicators (KPIs), and the comparison of MWG & JADE Services of the Maersk line. The research ascertains KPIs and their significance in the evaluation of the productivity of the terminal. Every month 3.5 (~4) vessels visited for JADE Service and for MWG Service it remained 3.4 (~4). An approximately equal number of vessels visited the terminal for both Services. It is pertinent to mention that the same quay crane operators and quay cranes were employed for handling containers of both services, conversely, Gross Moves Per Hour for JADE Service has persisted greater throughout the year than MWG Service except during the months of May & Dec 21.

There is a possibility of improving the productivity of the container terminal by ensuring the effective dispersal of resources. Generally, the average turnaround time of JADE Service continued to remain higher than MWG Service due to more container moves requiring a prolonged stay of vessels at the terminal. Moves of STS crane CC24 persisted highest i.e., 27.46 per hour which is the maximum of all STS Cranes available at QICT whereas average moves of STS Crane CC1 were recorded lowest i.e., 18.80 moves per hour. The productivity of operator 4 remained 58 % more than the lowest performing operator 2 additionally, the study found that operative productivity is affected by external elements which are out of control of QICT management such as weather interruptions and tidal effects. Port Qasim is a multi-purpose port with fishermen, ferry, automotive, containers, and liquid bulk freight terminals.

The study has encountered certain limitations, primarily stemming from constraints such as a limited amount of data spanning

one year and concerns regarding dataset confidentiality posed by the data providers. A comparison was performed between the two liner services of Maersk Line i.e., MWG and JADE services. Literature is scarce for Pakistan's maritime sector which made it difficult to conduct the regional literature review. The conclusions of the research are based on data obtained from the QICT. The data obtained is limited, therefore it restricts to facilitate of the use of other Key Performance Indicators (KPIs).

The Research contributes to the productivity enhancement of MWG Service and the vessel productivity at QICT. The variables affecting the vessel productivity at a container terminal (CT) under analysis conclude as follows:

- Berth/Wharf number vs Productivity graph in Figure 6 illustrated that number 07 wharf/berth is the most productive one for MWG service during the port calls done by the container vessels of the service.
- This is due to the distance of the stacking yard designated for MWG service being much nearer from wharf number 07 as compared to that of wharf number 05 and 06.
- Yard utilization drives vessel productivity in such a manner that (in Figure 7) it was interpreted as an inversely proportional relationship between vessel productivity and yard utilization.
- Productivity relative to the Number of Quay cranes used (Figure 8) determined that less or greater number of quay cranes used causes a reduction in vessel productivity while the effective number of cranes used makes the vessel operation more productive. a higher quantity of cranes can lead to reduced productivity due to increased congestion of ITVs (Internal Transport Vehicles) within the terminal.
- Vessel type concerning its construction because of the location of accommodation and superstructures as a hurdle also affects the productivity during vessel operations.
- Graphs under Figures 9, 10, and 11 showed that some STS/QC operators are performing below average or on average and some operators are up to the mark.

The comparative analysis between the liner services of MWG and JADE is performed for the vessel productivity enhancement of MWG service at QICT. Both the services were under the vessel operatorship of Maersk Line. Comparing the vessel traffic of both the services the results showed that there is an approximately equal number of vessels calling QICT every month.

6.2 RECOMMENDATIONS

From the conclusions drawn in this study, the following specific recommendations are made:

6.2.1 Enhance Berth Planning Efficiency:

The variability in vessel arrival times and the challenges posed by multiple vessels awaiting berth demand an emphasis on more efficient berth planning. Develop sophisticated algorithms and real-time monitoring systems to optimize berth allocation, taking into account weather conditions and vessel schedules. However, Berth 7, as highlighted, is the most productive berth for MWG Service. This is likely due to its proximity to the designated stacking yard for MWG Service. Berth 7's efficiency may also be influenced by factors such as quay crane availability and yard access. To optimize the utilization of Berth 7, consider the following:

- **Dynamic Allocation**: Implement a dynamic berth allocation strategy that considers real-time factors like vessel schedules, weather conditions, and congestion levels.
- **Efficient Yard Management**: Coordinate closely with the yard management team to streamline container movements to and from Berth

6.2.2 Optimal Number of Cranes for Jade Service:

Determining the optimal crane count for Jade Service is contingent on several key factors. These include aligning crane numbers with demand and congestion levels within the terminal, establishing contingency plans to address maintenance and downtime, ensuring operational flexibility to adapt to fluctuations in

demand, all of which collectively contribute to achieving an efficient and productive crane deployment strategy.

6.2.3 Enhance STS Crane Productivity Through Proactive Maintenance

A dedicated focus on proactive maintenance for STS cranes is vital. The low productivity observed in CC1 to CC6 cranes is primarily attributed to machinery failures and fair wear & tear. By allocating additional resources to preemptive maintenance, QICT can effectively mitigate these issues, ensuring uninterrupted operations and elevating overall productivity.

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Sino-US Escalating Competition in Indo-Pacific Ocean: Challenges and Choices for Pakistan

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Abstract

The Indo-Pacific Ocean has gained significant international focus in the 21st century. It plays a crucial role as a habitat for many countries and enables more than 80% of global trade through its sea routes. The region's abundant energy resources make it extremely important, leading great powers to compete for dominance. The rise of China in the region, together with the declining power of the United States, has forced the United States to assertively cultivate new alliances with regional states and strengthen existing partnerships. Simultaneously, China is making significant investments in neighbouring states to create and strengthen diplomatic relations. The ongoing power struggle between the US and China is having a negative impact on the neighbouring states in the region. The United States and India's strategic cooperation has prompted the area to indulge in an arms race, due to the longstanding hostilities with Pakistan. Due to Pakistan's crucial involvement in China's vital initiative, the China-Pakistan Economic Corridor (CPEC), the country is unable to disengage from the complexities of intense competition among major powers.

Keywords

Indo-Pacific Ocean, Pakistan, United States of America, Challenges, SLOCs

1. Introduction

The Indo-Pacific comprises the Indian and Pacific Oceans that are connected through the Malacca Strait.[1] Stretching from the eastern

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coast of Africa to the western coast of the Americas, this enormous body of water encompasses the oceans of South Asia, Southeast Asia, and Northern Australia. The geopolitical and strategic significance of this region is noteworthy due to crucial maritime lanes, and diverse ecosystems. The phrase “Indo-Pacific” is frequently employed to emphasize the interconnectivity between the Indian and Pacific Oceans, as well as the geopolitical and economic dynamics that are at play within this maritime area. The concept in question has garnered significant attention in global discourse, notably within the realm of geopolitical and security deliberations. The region thrives through global trade. Its littoral states are endowed with energy resources. About 80% of world trade is carried out over the water ways, of which 60% is conducted through the sea lanes of communications housed by the Indo-Pacific. This region constitutes 65% of the world population.[2] The Indo-Pacific Economic Framework, recently formed by the USA and twelve regional states constitute 63% of world GDP.[3] The region's abundance of human capital, trade opportunities, and energy resources make it an appealing center of interest for global powers. The rise of China as a competitor, however, has become a challenge to US supremacy. The South China Sea states also have internal territorial disputes that exacerbate China-USA competition. Overall, the region has evolved as a center stage of world politics.

China’s rise over the past decades, through soft power, appears to be reshaping the global political landscape and China is being viewed as a challenger to the existing world order dominated by the USA as sole super power. As a result, both the US and China are increasingly involved in engaging regional states in economic and security pacts leaving less chance for smaller states of the region like Pakistan to stay non-aligned. This paper aims to analyse American and Chinese escalating competition in the Indo-Pacific Region and study the impact on Pakistan.

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1 *Encyclopaedia Britannica,* “Strait of Malacca,” last modified November 18, 2023,

2 Amit Dev, “China’s Rise and the Implications for the Indo-Pacific,” *Observer Research Foundation,* 2022,

3 “Fact Sheet: In Asia, President Biden and a Dozen Indo-Pacific Partners Launch the Indo-Pacific Economic Framework for Prosperity,” *White House*, 2022,

2. Methods, Literature and Theoretical Application

States in the region and beyond including US, Russia, China, India, France, Japan, Australia, the United Kingdom and the states of the European Union are developing their marine potential in the Indo-Pacific.[4] On one hand, the US wants freedom of navigation, uninterrupted access to oil along with the containment of China. By contrast, China wants to stop the domination of any global or regional power in the region for the smooth flow of energy supply for its potential industry. Similarly, India, the rising regional power wants to secure its interests through the protection of sea lanes and Pakistan is pursuing its own maritime interests through the Gwadar port. In the Indo Pacific region, Built with Chinese support, it has the potential to become an energy hub, being the deepest and one of the most strategically vital ports in the world. Resultantly, regional and global powers are strongly determined to safeguard their interests in the Indo-Pacific area.

Against this backdrop, the Indo-Pacific region will continue to draw the attention of major global powers who are vying for access to crucial trade routes and plentiful energy resources, given the region's growing significance in marine trade and heightened strategic interests. The current situation poses multiple challenges for secure navigation, which has significant impact on the socio-economic progress of the area. As a result, the changing patterns are likely to increase maritime operations in the Indo-Pacific Region, including international trade, the establishment of economic partnerships to achieve strategic goals, and the expansion and consolidation of ports. The region will become more complex and contested than ever before as a result of this transformation.[5]

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[4] Pervaiz Iqbal Cheema, “Indian Ambitions in the Indian Ocean and the Pacific Rim: The Response of Global and Regional Powers,” *The Free Library,* December 31 2012,

[5] Nazery Khalid, “The Role of the Indian Ocean in Facilitating Global Maritime Trade,” in *the Security of Sea Lanes of Communication in the Indian Ocean Region*, ed. Shahriman Lockman (Kuala Lumpur: Institute of Strategic and International Studies Malaysia*,* 2007).

T. V. Paul denotes balancing as a tool to contain a rising power failing which the balance of power is not likely to be achieved.[6] The balance of power theory, which is based on realist viewpoints, suggests that states strive to uphold stability in the international system by averting the rise of a sole dominant power hence, it can be used to assess how the governments strategically are aligning themselves to counteract the influence of both China and the US in the Indo-Pacific region, where both countries are fighting for influence. The complex interplay of alliances, military capacities, and diplomatic strategies in the Indo-Pacific region can be comprehended by applying the Balance of Power theory which explains how states strive to protect their interests and prevent the excessive dominance of a sole power in the area. To achieve the basic goals of this research activity, the paper is started with analysis of current literature on Indo-Pacific region, its essentialness and security dimensions. The study looks into present weaknesses in existing literature in the regional power politics and make it to come up with current state of affairs with clarity. It further attempts to answer the question that strategic and economic realms of U S of America and China are descriptions of their cross-offensive paradigms.

After building basis of the research dialogue, the paper attempts to comprehend the influence of U S of America and power shift in the Indo-Pacific Ocean. Efforts have been made to look into the policy shift implications by four major power contenders in the Indo-Pacific Region i.e., U S, India, China and Pakistan. It is evident that China has placed growing emphasis on a "soft power" approach, utilizing cultural, economic, and diplomatic endeavors to augment its global influence. On the other hand, the historical perspectives link the U S, especially during the Cold War period, with a primary dependence on "hard power," which includes military alliances, interventions, and economic influence to attain geopolitical goals. While concluding the issue under research, certain recommendations are presented on the future issues leaving the space for the contending powers to look their matters peacefully.

[6] T.V. Paul, John J. Wirtz, and Michel Fortmann, *Balance of Power: Theory and Practice in the 21st Century* (California: Stanford University Press, 2004).

3. Sino-US Strategic Competition in Indo-Pacific Region

The US conduct of international relations is increasingly becoming dominated by her efforts to contain China. The US has, therefore, increased its involvement in Asia, especially the Indo-Pacific Region over past few decades and came up with various forums and multiple alliances, commencing with the Pivot to Asia policy in the 1990s. The Quadrilateral Security Dialogue (QUAD) launched in 2007 initiated a closer, but informal security cooperation in the region comprising US, India, Japan and Australia. It aimed at forestalling Chinese domination in the region, with announced purpose of keeping the Indo-Pacific Ocean's Sea lanes free from any political or military influence.[7]

Furthermore, a modified focus after President Donald Trump's visit to Asia in 2017 resulted in passing of the Asia Reassurance Initiative Act (ARIA) on 31st December 2018. The ARIA allocated US$1.5 billion for undertaking a range of US programs in East Asia and Southeast Asia to 'develop a long-term strategic vision and a comprehensive, multifaceted, and principled US policy for the Indo-Pacific region.' Since then, the US has been rejuvenating existing ties and forging new alliances with Indo-Pacific states. For instance, the consolidation of AUKUS—a trilateral security partnership for the Indo-Pacific region in 2021—the formation of a new quadrilateral group I2U2 (named after the member states, namely India, Israel, the United Arab Emirates, and the United States) in 2021, and an economic framework initiated by the US known as the Indo-Pacific Economic Framework for Prosperity (IPEF) in 2022 were added to further strengthen these alliances. They aim at the territorial containment of China, particularly intervening in Chinese Sea Lines of Communications (SLOCs) in the Malacca Strait when needed. Through these strategies, alliances, and forums, India has been termed a US strategic partner, thus considered a US bulwark against Chinese power.

[7] Soumyodeep Deb, and Nathan Wilson, "The Coming of Quad and the Balance of Power in the Indo-Pacific," *Journal of Indo-Pacific Affairs* 4, no. 3 (2021): 67-80.

The AUKUS which is a security alliance, comprising Australia, UK and US was concluded in 2021, focuses on containment of China.[8] Under this pact, the US will be providing nuclear submarines and back up technology to Australia. On the other hand, I2U2 is a group which comprise Israel, India, UAE and USA to collaborate in economic, technological and private sectors, enhancing cooperation in trade, infrastructure development and renewable energy. It has also been termed as a new Quad by some writers.[9]

Moreover, the Indo-Pacific Strategy of the U S published in February 2022 is based upon the pillars i.e., consolidating partnerships, deepening coalitions and strengthening alliances; enhancing trade relations with the states and creating new opportunities to engage partners; and increasing deterrence and encouraging long term peace and stability in the region.[10]

The Indo-Pacific Economic Framework (IPEF) is another initiative by the Biden administration to offset the negative consequences of the US walking out of the Trans Pacific Partnership. It includes Australia, Brunei Darussalam, Fiji, India, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand, and Vietnam. It aims at connectivity, trade and maintenance of supply chains, clean energy, de-carbonisation and infrastructure development, tariff concessions and anti-corruption.[11] The USA has provided $150 million to start this forum.

Amid the competition with China, the USA is trying to induce peripheral states to join her in this effort. The USA has even started coercing non-aligned states to move away from China, forcing binary choices upon them like potential economic and diplomatic repercussions or joining the alliances led by the United States. Presently Pakistan appears to be facing similar pressures due to its

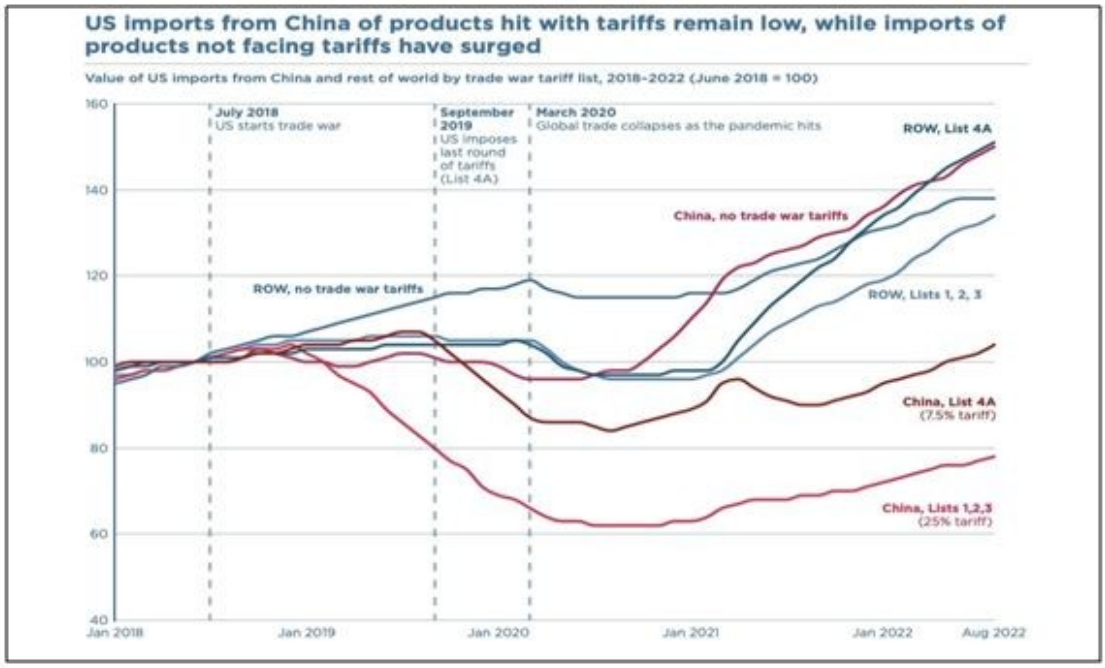
[8] "Aukus: UK, US and Australia Launch Pact to Counter China." *BBC News,* September 16, 2021.

[9] Anirban Bhaumik, "I2U2 Summit: India, Israel, US & UAE to Form New Bloc," *Deccan Herald*, June 16, 2022.

[10] "Indo-Pacific Strategy of the United States February 2022," *White House*, February, 2022.

[11] "Fact sheet: In Asia, President Biden and a Dozen Indo-Pacific Partners Launch the Indo-Pacific Economic Framework for Prosperity," *White House*, May 23, 2022..

long-term strategic relationship with China. Consequent to this, demonization of China Pakistan Economic Corridor (CPEC) by USA, her allies and India is also vivid.[12,13] Likewise, US is also trying to contain China in multiple technology and non-technology domains including acquisition of high-end technology through digital authoritarianism, denying access to artificial intelligence, surveillance technologies, and satellite-based navigation not only for military uses but in 6G telecommunications for civilian use. Both states imposed heavy tariffs on each other's products as tit for tat measures of trade war. This discernibly affected the trade between them, and countries like Vietnam benefitted as a consequence.[14]



Source: Peterson Institute for International Economics 2022

In response to US containment efforts, China has also made attempts to enhance her influence in the region by developing politico-

[12] "China Lashes-Out At The US For Demonizing CPEC, Meddling In Pakistan-China Ties," *EurAsian Times Desk*, January 23, 2020.
[13] "CPEC truly transformative for Pakistan: Pakistani senator," *Global Times,* July 31, 2022.
[14] Vikas Mishra, "The Great U.S.-China Tech Decoupling: Perils of Techno-Nationalism," *Observer Research Foundation*, March 4, 2023.

economic alliances with the Indo-Pacific states.[15] The Belt and Road Initiative (BRI) that commenced in 2013 helped China in expanding her sphere of economic influence. The US, and her allies have sometimes viewed this as a strategic initiative to dominate the world economy and supply chains. Furthermore, The Regional Comprehensive Economic Partnership (RCEP) in 2020 and China-Solomon Island Pact in 2022 also contributed in expanding Chinese influence around the globe in general, and in the region in particular.

Cognizant of US efforts to isolate and contain it, China started taking counter measures to reduce US influence, especially in the Western Pacific. China has been engaged with the South Pacific countries for over three decades through various regional forums such as the Pacific Islands Forum (PIF) and China Pacific Island Countries Forum started in 1990. China provides about $1 million each year to the EDCF secretariat. In 2020, China added a $1.9 million fund to support this region's response against COVID -19.[16]

Moreover, the Regional Comprehensive Economic Partnership (RCEP), led by China, is a regional alliance with the purpose to enhance free trade in goods and services, investments, economic and technical cooperation in the region. It comprises Australia, New Zealand, Brunei Darussalam, Cambodia, China, Japan, Laos, Singapore, Thailand and Vietnam.[17]

The China-Solomon Islands Pact is a bilateral security agreement that was inked between China and the Solomon Islands in April 2022. It essentially focuses on boosting the Solomon Islands' national security capacity. This Pact also encompasses cooperation in humanitarian assistance, disaster response and measures for maintaining social order. Under this pact Chinese ships can "make ship visits to, carry out logistical replacement in, and have stopover and transition in Solomon Islands," In addition, Chinese forces can be

[15] Weixing Hu, and Wang Meng. "The US Indo-Pacific Strategy and China's Response," *China Review* 20, no. 3 (2020): 143-176.
[16] Hu and Meng, "The US Indo-Pacific Strategy."
[17] Peter A. Petri, and Michael Plummer. "RCEP: A New Trade Agreement That Will Shape Global Economics and Politics," *Brookings*, November 16, 2020.

deployed to “protect the safety of Chinese personnel and major projects.”[18]

There is a possibility that a Cold War between China and USA may take place. Some believe that it has already commenced in the shape of trade, diplomacy, political, economic and technological conflicts. If it translates into bloc formation it may lead to proxy wars amongst the major powers using smaller partner states as battle grounds. In such a scenario the smaller states will come under tremendous pressure. The US- China competition induces pressure on the smaller states and forces them to choose sides.

4. The Pakistan-China-India Dynamics: The Challenges and Choices for Pakistan

Strategic competition in the Indo-Pacific is likely to have an adverse impact on South Asia. Pakistan holds a key position in South Asia and this cannot be separated from the politics of the Indo-Pacific region. Pakistan occupies a unique place in the current regional power struggle due to its alliance with China, support for Russia, and historical rivalry with India, which is backed by the United States. This strategic approach has the potential to have global ramifications.

America’s tilt towards India is adding to the security dilemma for Pakistan. The nuclearized Indo-Pacific possesses the potential to accelerate the arms race in the region as a result of AUKUS. Besides, her extended role in ASEAN, and relationship with Asian and African states, India’s strategic alliance with the USA has amplified her assertiveness in bilateral as well as regional relations, especially with Pakistan. Despite the fact that India has provided assistance to militant organizations in Pakistan and has been accused of participating in events that resulted in Chinese casualties within Pakistani territory, the West turns a blind eye to Indian actions. Indian military acquisitions of billions of dollars from USA, Europe and Israel are fast upsetting the balance of power in the region, thereby

[18] Richard McGregor, “Solomon Islands Pact Cements China's Pacific Power Status,” *Nikkei Asia*, April 19, 2022.

provoking an arms race.[19] Pakistan's reduced conventional military capability as compared to India could result into a much-lowered nuclear threshold in the use of nuclear weapon in case of conflict, putting South Asia at the risk of nuclear exchanges in case of a Pakistan-India war. US tilt towards India and her potential support is also affecting the conflict resolution in South Asia, especially with reference to Pakistan's stance on Kashmir.[20] USA appears to be comfortable with India positioning itself as a regional actor asserting dominance concurrently as a counterforce against China. So, the rise of India can have significant impact on the precarious stalemate between the two states. With the increase of Indian power, its capability to strategically and economically encircle Pakistan will also increase.

Given the current unstable power dynamics in South Asia, worsened by the increasing competition between major powers in the Asia-Pacific region, Pakistan could use a diverse strategy to improve its relations with India and other regional countries. In order to resolve long-standing conflicts and promote mutual trust, traditional diplomatic strategies such as persistent communication and conflict resolution techniques are essential. Initiatives for economic cooperation, such expanded trade and cooperative infrastructure projects, can also support stability in the region. Non-traditional approaches, such as cultural exchanges and sports diplomacy, as well as technical and environmental collaboration, provide opportunities to forge positive narratives and shared interests between nations. On other hand, Pakistan is progressively involved in increasing relationships with states of Central Asia to utilize its geostrategic location as an access point to the Indian Ocean. This has principally been made into a reality with new China's constructed port facility at Gwadar. Sino-Pak strategic ties have emerged to be significant for its security, stability and prosperity over the last decade.

Pakistan occupies a place of geo-economic and strategic significance in the region: the Indian Ocean and its relative proximity

[19] Abdul Qadir Khan, "US-India Strategic Bargaining and Power Balancing in South Asia," *JPRSS* 1, no. 2, (2014).
[20] Sadaf Farooq, Sadia Kazmi, and Javaria Javed, "Indo-US Strategic Partnership: Implications for Pakistan," *Policy Perspectives* 15, no. 1(2018): 3-20.

to the Straits of Hormuz. Its vicinity to Central Asian States, China and Russia, ability to act as a land bridge for Afghanistan and East Europe make it an important connectivity hub for enhanced trade and connectivity, as well as providing these states transit facilities for their seaborne trade. But, despite having 1001 km coastline with the Indian Ocean, Pakistan receives less significance in US 'Indo-Pacific Strategy' and US sponsored regional alliances. However, Pakistan experiences much more pressure from the US due to evolving geo-strategic environment wherein Indian relevance to security interests dominate.

Being an ally of China and partner in BRI, Pakistan has become the victim of proxy wars. CPEC carries great potential for Pakistan's socio-economic development that will complement Pakistan's traditional as well as non-traditional security. CPEC provides Gwadar as an alternative to a disturbed Malacca Strait. Pakistan should not compromise on the CPEC. Pakistan also needs to strengthen her ties with regional and extra regional states including Shanghai Cooperation Organisation and ASEAN countries as well as join other economic forums.

Stability in Afghanistan is considered crucial to the realisation of Pakistan's reoriented national security policy. Therefore, all possible efforts must be made to bring peace and stability in Afghanistan. For that Pakistan can play a significant role as it has already acted as a facilitator in the US-Taliban peace talks. Afghanistan can be engaged politically, diplomatically as well as economically to project the softer image of Pakistan in Afghanistan. Engagements with people, cultural exchange programs, economic cooperation, humanitarian assistance, media engagements, diplomatic outreach, security cooperation and crisis management and conflict resolution are need of the hour to secure the Western border of Pakistan. Facilitating students by providing them scholarships for higher education in Pakistan may be enhanced. This will help Pakistan to construct its positive narrative in Afghanistan for long-term sustainable relations.

Avoiding bloc politics, Pakistan should not ally with any major power in new cold war. India has for years maintained the policy of non-alignment. Pakistan can also strengthen economic relations with

Russia who can be a better substitute for an energy deficient state like Pakistan by providing comparatively cheaper energy supply.

Lastly, Pakistan has been partnering with the US in armed conflicts and has suffered a lot particularly in the aftermath of war against terror. Being a global hegemon, US has her due significance and Pakistan is not in a position to ignore her. While not compromising own interests, Pakistan should maintain good relations with both; the US and China. Pakistan should balance relations with US, China, Russia, EU, Middle East, Far Asia and Africa. We should not fall a prey to become proxy of any of the major powers.

5. Conclusion

One cannot negate the significance of oceans. The Indo-Pacific Ocean region has emerged as a center stage of world politics where major powers are aggressively involved to exert their influence. The vital choke points of the Ocean are making the trade routes more vulnerable. Shipping lanes can be closed down in the case of any escalation between the two major rivals US and China their respective allies. The scenario may further worsen if the escalation deepens in the Ocean, affecting other littoral states directly and causing energy and economic crises throughout the globe.

India's ties with the US and her efforts to project her as a member of Nuclear Supplier Group can have adverse effects on Indo-Pak rivalry. India seeks to become permanent member of UN Security Council which is also unfavorable for Pakistan. Its growing dependence on China is helping Pakistan to develop economically, but it is also widening the diplomatic gap between US and Pakistan. Pakistan needs to be cautious and act sensibly to avoid any trouble in the future. It should develop working bilateral and trade relations with India. Pakistan could emulate China in this regard. Despite their strategic and economic competition, keeping the conflicts aside, China and India as well as US and China, are maintaining their trade relations. Their interdependence can help minimise the possibility of armed conflict between them. The National Security Policy of Pakistan 2022, priorities geo-economic and human security. In line with that, Pakistan can also conduct trade with India in a balanced manner. A

stronger economy, with happier and healthier human capital, will complement our ability to fight the challenges of the future effectively.

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Usage of Term' Maritime'' and its Impacts on the Literature on China-Pakistan Economic (Maritime) Corridor (CPEC)

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Abstract

This paper aims to construe literature-based research to highlight the significance of the relevant terminology in the 'maritime' domain: usage and utilisation. It intends to create a harmony-based information delivery within the literature for information to the stakeholders to understand the global maritime issues, concerns, updates, policies, and laws. Given that, fifty articles are selected from various journals to review the usage of the term "maritime" in the literature in different contexts, including oceans, ports, shipping and coasts. Results will be based upon the selected literature following the right path in translating the term 'maritime.' The research will analyse the future options for social, political and natural (behavioural) sciences' discourses in the 'maritime' domain under the China-Pakistan Economic Corridor (CPEC). The idea presented through this paper is that CPEC is a maritime corridor connecting China with Pakistan, Kashgar Port, and Gwadar Port.

Introduction

Language plays an instrumental role in governance affairs based on social, political, and economic discourses.[1] It is a communication medium through which scientific information and human-human and human-nature relationships are identified, valued, processed, and exercised.[2] It is also highlighted that government

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[1] Thomas Ricento, *Language Policy and Political Economy: English in a Global Context* (Oxford University Press, 2015).

[2] L. J. Bracken and E. A. Oughton, '"What Do You Mean?" The Importance of Language in Developing Interdisciplinary Research', *Transactions of the Institute of British Geographers* 31, no. 3 (2006): 371–82, https://doi.org/10.1111/j.1475-5661.2006.00218.x.

affairs are legalised through a medium of the social or political movement to define the human-nature-science relationships, and all this process is conducted through communication.[3] Any campaign in any system of governance offers significant legislative development, which may also impact international relations. Moreover, international relations are also legalised through a medium of communication between two or more states, and this exercise affects the future development of literature.[4] The mentioned developments are circular in nature, and any future discourse of such development impacts the future of political, scientific and international relationships.

English is the official language of the Islamic Republic of Pakistan. Unfortunately, it is still ambiguous, which English medium of communication is being followed.[5] A heterogeneous usage of terminologies portrays that the English language medium in Pakistan is Pakistani.[6] Such communication perplexities have caused a decline in literature and have triggered confusion among the policy, governance, and legislative patterns. Following the given hypothesis, the term' maritime' is also misunderstood, and it is evident through the so-far-developed Pakistan-based academic work related to it.[7] One potential reason behind such misconception is the paraphernalia of the term, which is limited to the Pakistan Navy or the renowned port city of Karachi. Thus, the general perception of the term in social science practice (such as in journalism or academia) emerged due to the naval warfare of 1971[8] or the *Tasman Spirit Oil Case* of 2003.[9]

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[3] Nelson Cowan, 'Short-Term Memory, Working Memory, and Their Importance in Language Processing', *Topics in Language Disorders* 17, no. 1 (November 1996): 1–18.

[4] denice Welch, Lawrence Welch, and Rebecca Piekkari, 'Speaking in Tongues : The Importance of Language in International Management Processes', *International Studies of Management & Organization* 35, no. 1 (1 January 2005): 10–27, https://doi.org/10.1080/00208825.2005.11043723.

[5] Furrakh Abbas, Azhar Pervaiz, and Faheem Arshad, 'The Competing Status of Urdu and English after Declaration of Urdu as Official Language in Pakistan', *Journal of Research (Urdu)* 34, no. 1 (2018): 142–58.

[6] Fauzia Shamim, 'Trends, Issues and Challenges in English Language Education in Pakistan', *Asia Pacific Journal of Education* 28, no. 3 (1 September 2008): 235–49, https://doi.org/10.1080/02188790802267324.

[7] See for example, Aiysha Safdar, 'The China-Pakistan Economic Corridor – Its Maritime Dimension and Pakistan Navy', *Strategic Studies* 35, no. 3 (2015): 1–19.

[8] Vijay Sakhuja, 'Pakistan's Naval Strategy: Past and Future', *Strategic Analysis* 26, no. 4 (1 October 2002): 493–507, https://doi.org/10.1080/09700160208450064.

However, the term has gained prominence since the establishment of the China-Pakistan Economic Corridor (CPEC), which is being developed through Bilateral Investment Treaties (BITs) and Free Trade Agreements (FTAs), basically aiming for connectivity of Western China with the Port of Gwadar.[10] Therefore, recent developments have caused more complexity in defining the term and understanding its usage in diverse discourses.

The term 'maritime' is usually referred to as the business related to oceans and shipping.[11] The usage of the term 'maritime' in diverse disciplines, albeit in ways that create complexities in the literature, such as in management sciences disciplines, is contextualised as 'maritime management,' which means managing the shipping, ports, and logistics.[12] Meanwhile, in inter-disciplinary courses, the term 'maritime' loses its significance. For instance, each business has different terminologies for managing the marine

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[9] Saima Mian and Suzan Bennett, 'The Tasman Spirit Oil Spill: Implications for Regulatory Change in Pakistan', *Disasters* 33, no. 3 (2009): 390–411, https://doi.org/10.1111/j.1467-7717.2008.01080.x.

[10] Asif H. Qureshi, 'China/Pakistan Economic Corridor: A Critical National and International Law Policy Based Perspective', *Chinese Journal of International Law* 14, no. 4 (1 December 2015): 777–99, https://doi.org/10.1093/chinesejil/jmv045.

[11] Barry Zondag et al., 'Port Competition Modeling Including Maritime, Port, and Hinterland Characteristics', *Maritime Policy & Management* 37, no. 3 (1 May 2010): 179–94, https://doi.org/10.1080/03088831003700579; Hyung-Sik Nam and Dong-Wook Song, 'Defining Maritime Logistics Hub and Its Implication for Container Port', *Maritime Policy & Management* 38, no. 3 (1 May 2011): 269–92, https://doi.org/10.1080/ 03088839.2011.572705; Nitin Agarwala, 'Role of Policy Framework for Disruptive Technologies in the Maritime Domain', *Australian Journal of Maritime & Ocean Affairs* 0, no. 0 (22 March 2021): 1–20, https://doi.org/10.1080/18366503.2021.1904602.

[12] Lodewijk Abspoel et al., 'Communicating Maritime Spatial Planning: The MSP Challenge Approach', *Marine Policy*, 7 March 2019, 103486, https://doi.org/10.1016/ j.marpol.2019.02.057; A. A. Akaso, 'Oceans Policy as a Sustainable Tool for the Regulation of the Marine Environment', *International Journal of Advanced Legal Studies and Governance* 3, no. 1 (2012): 71–77; Hermanni Backer, 'Regional Work on Prevention of Pollution from Ships in the Baltic Sea – A Paradox or a Global Forerunner?', *Marine Policy* 98 (1 December 2018): 255–63, https://doi.org/10.1016/j.marpol.2018.09.022; Jonathan P. Atkins et al., 'Management of the Marine Environment: Integrating Ecosystem Services and Societal Benefits with the DPSIR Framework in a Systems Approach', *Marine Pollution Bulletin* 62, no. 2 (2011): 215–26; Bruce Farthing, *International Shipping: An Introduction to the Policies, Politics and Institutions of the Maritime World*, 2nd edition (London: Informa Pub, 1993); Uwe Breitling and GTZ Team Leader, 'Sustainable Shipping and Port Development', in *5th Regional EST Forum in Asia*, 2010.

environment, ocean resources, border control, and maritime-related implementing authorities.[13] In these interdisciplinary courses, the terminologies used are ocean management, marine environmental management, or maritime security management.

Furthermore, the terminologies of maritime law, ocean policy, marine environmental protection law, public maritime law, and private maritime law are different concepts and phenomena.[14] Similarly, marine engineering is different from ship and environmental engineering. Moreover, the recent emergence of climate change and Sustainable Development Goals (SDGs) has provided significant literature development opportunities related to oceans.[15] Therefore, marine environment-ology (ecology), coastal management, ocean and coastal management, marine science, and coastal sciences have emerged as new disciplines. However, the developing literature in the field of maritime in Pakistan has ignored the correct usage of different terminologies related to 'maritime.' Thus, the terminology related to the 'maritime domain' throughout the literature is misused or confused.

The germane of the term 'maritime' in the context mentioned above will be vast because the recent legislative advancements for exploiting ocean resources have opened venues of debates among social and natural scientists. Hence, it is also necessary to establish correct usage of the terminology related to 'maritime' jargon. Otherwise, irrelevant or inaccurate use of terms will impact future literature developments, such as policy, guidelines, literature,

[13] Edgar Gold, 'International Maritime Law in Transition: New Challenges for Education and Training', *Marine Policy* 13, no. 3 (1 July 1989): 178–92, https://doi.org/10.1016/0308-597X(89)90054-7; Blair Gibb, 'Dredging, Environmental Issues and Port Experience in the United States', *Maritime Policy & Management* 24, no. 4 (1 January 1997): 313–18, https://doi.org/10.1080/03088839700000040; Atkins et al., 'Management of the Marine Environment'; Akaso, 'Oceans Policy as a Sustainable Tool for the Regulation of the Marine Environment'.

[14] Akaso, 'Oceans Policy as a Sustainable Tool for the Regulation of the Marine Environment'; A. D. Couper, 'Environmental Port Management', *Maritime Policy & Management* 19, no. 2 (1 June 1992): 165–70, https://doi.org/10.1080/03088839200000023.

[15] Mohammad Mahmudul Islam and Md Shamsuddoha, 'Coastal and Marine Conservation Strategy for Bangladesh in the Context of Achieving Blue Growth and Sustainable Development Goals (SDGs)', *Environmental Science & Policy* 87 (1 September 2018): 45–54, https://doi.org/10.1016/j.envsci.2018.05.014.

legislation or budget.[16] Therefore, through this research, the attempt is to establish significant meanings of the term 'maritime,' its persistent and consequential usages in social, economic, and political sciences, and the awareness of the subjects related to it, in order to help academia, social scientists, journalists, policymakers[17] and institutions for effective translation, implementation and consciousness of CPEC under the Belt and Road initiative (BRI) as a maritime corridor.[18]

ORGANISATION OF HISTORICAL DEVELOPMENT OF THE TERM 'MARITIME'

The scope of this research is quite pragmatic. Thus, rather than digging deep into ancient history, it is necessary to observe the meanings of the term 'maritime' from contemporary history. For this purpose, the legal reference to stage the term is quite significant, as 'maritime law' is derived from *'lex Maritima,'* and its reference could be found in medieval Western Europe's policy or judicial documents.[19] At the beginning of international trade, 'mercantilism' (*Lex Mercatoria*) became common. It is one of the theories that 'maritime' emerged from 'mercantile.' Anyhow, the term 'maritime' has existed in the English language since the Middle Ages (between the 5th and 15th Century), and in the early 15th Century, which is also referred to as the 'age of exploration' in British History, and the then British Admiralty Courts frequently used it.[20] However, 'admiralty' is somehow different from 'maritime,' and the former governs the relationships between the private parties chartering the ships.[21] Thus, the term 'maritime' is quite

[16] For example, the incorrect usage of the term see, Shafiq Kayani, 'THE OCEAN Life, Livelihood and Sustainability Opportunities and Challenges for Pakistan', *Maritime Study Forum* (blog), 10 June 2021, https://www.maritimestudyforum.org/the-ocean-life-livelihood-and-sustainability-opportunities-and-challenges-for-pakistan/.

[17] All together Social Scientists.

[18] Prakash Panneerselvam, 'Maritime Component of China–Pakistan Economic Corridor (CPEC): India–China Competition in the Arabian Sea', *Maritime Affairs: Journal of the National Maritime Foundation of India* 13, no. 2 (3 July 2017): 37–49, https://doi.org/10.1080/09733159.2017.1412577.

[19] William Tetley, 'The General Maritime Law - The Lex Maritima', *Syracuse Journal of International Law and Commerce* 20 (1994): 105.

[20] Geoffrey J. Martin, *All Possible Worlds: A History of Geographical Ideas*, *OUP Catalogue* (Oxford University Press, 2005), https://ideas.repec.org/b/oxp/obooks/9780195168709.html; Kenneth J. Andrien, 'Age of Exploration, c. 1500–1650', in *The Ashgate Research Companion to Modern Imperial Histories* (Routledge, 2012).

[21] Chester D. Hooper, 'Carriage of Goods and Charter Parties', *Tulane Law Review* 73 (1999 1998): 1697; R. Glenn Bauer, 'Effects of War on Charter Parties', *Tulane Maritime Law Journal* 13 (1989 1988): 13.

generic in the British legal system, and there is a scholarly dispute regarding its definition.[22] The customary practitioners argue that the term covers a vast range of oceanic issues, including public and private, scientific, social, and political. Conversely, modern scholars support their arguments by establishing the universal Charter of the Sea, i.e., the United Nations Convention on Law of the Sea (UNCLOS), which governs the State relations and practices related to the oceans. Thus, UNCLOS, as the law of the sea, is separated significantly from the 'maritime law.'[23]

Admiralty Law is also referred to as 'dry law' because it is penned at land, between the charter parties, which could be related to marine insurance, bill of lading, chartering of the ships, cargo, and international commercial terms (INCOTERMS).[24] The other part, broadly known as maritime law, is the 'wet law' because it deals with the incidents occurring at sea, such as salvage, collisions, wreck removal, causalities, damages, and liabilities.[25] This possibly is confusing because of the thin line between both, and for clarity, it could be understood by two legal terminologies, i.e., transaction and litigation.[26] Thus, within the meaning of 'transaction,' the admiralty law

[22] Joseph C. Sweeney, 'The Admiralty Law of Arthur Browne', *Journal of Maritime Law and Commerce* 26 (1995): 59; Brunson MacChesney, 'Marine Insurance and the Substantive Admiralty Law: A Comment on the Wilburn Boat Company Case', *Michigan Law Review* 57 (1959 1958): 555.

[23] 'United Nations Convention on Law of the Sea', came into force on 16 November 1994, (1833 UNTS 397) § (1982); United Nations Department on Social and Economic Affairs, 'Rio Declaration on Environment and Development: Application and Implementation', Report of the Secretary General, Commission on Sustainable Development (Fifth Session) (Geneva, Switzerland: United Nations Economic and Social Council, 12 October 1999), https://www.un.org/esa/documents/ecosoc/cn17/1997/ecn171997-8.htm; Patricia C. Bauerlein, 'The United Nations Convention on the Law of the Sea & (and) US Ocean Environmental Practice: Are We Complying with International Law', *Loyola of Los Angeles International and Comparative Law Journal* 17 (1994): 899, https://heinonline.org/HOL/LandingPage?handle=hein.journals/loyint17&div=37&id=&page=.

[24] Harold J. Berman and Colin Kaufman, 'Law of International Commercial Transactions (Lex Mercatoria)', *Harvard International Law Journal* 19 (1978): 221; James Allsop, 'Maritime Law - The Nature and Importance of Its International Character', *Tulane Maritime Law Journal* 34 (2010 2009): 555; Robert Force, Athanassios N. Yiannopoulos, and Martin Davies, *Admiralty and Maritime Law* (Beard Books, 2005).

[25] Hilton Staniland, 'Admiralty Law Legislation', *Annual Survey of South African Law* 2001 (2001): 779–88.

[26] Chi Carmody, 'Beyond the Proposals: Public Participation in International Economic Law Symposium: Interfaces: From International Trade to Econommic

is the focus, which may lead to litigation at any later stage, and 'litigation' mainly occurs as there are not any written agreements for the incidents occurring at sea, and the coastal State jurisdiction becomes relevant for any dispute resolution.

Owing to the technicalities of maritime law, the literature selected for this research is from seminal journals of ocean law, shipping governance and coastal policy, for example, Marine Policy, Ocean Development and International Law, International Journal of Marine and Coastal Law, and the World Maritime University Journal of Maritime Affairs. The selected literature comprehensively addresses the fact that there is a difference between public maritime law and private maritime law, and the usage of the terminologies in both further motivates the development of literature in management, social, and political sciences. Ocean governance, shipping (maritime) governance, integrated coastal zonal management (ICZM), fisheries management, maritime diplomacy, and marine environmental protection, as subjects of maritime politics, sociology, security, and management, are interdisciplinary in nature.[27] It can be observed that the usage of the terms for diverse disciplines or discourses or subjects is different, and the term 'maritime, therefore, originating from the legal practice, contains various connotations.

As it is somehow established that 'maritime' as an oceanic discipline is a complete and different science, it is about utilising the

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Law', *American University of International Law Review* 15, no. 6 (2000 1999): 1321–46; Brian Davenport, 'The UNCITRAL Model Law on International Commercial Arbitration: The Users' Choice', *Arbitration International* 4, no. 1 (1 January 1988): 69–74, https://doi.org/10.1093/ arbitration/4.1.69.

[27] Thia-Eng Chua, 'Coastal and Ocean Governance in the Seas of East Asia: PEMSEA's Experience', *Coastal Management* 41, no. 2 (1 March 2013): 99–119, https://doi.org/10.1080/08920753.2013.768517; Farthing, *International Shipping*; Verónica Caviedes, Pedro Arenas-Granados, and Juan Manuel Barragán-Muñoz, 'Regional Public Policy for Integrated Coastal Zone Management in Central America', *Ocean & Coastal Management* 186 (15 March 2020): 105114, https://doi.org/10.1016/ j.ocecoaman.2020.105114; Edward H Allison et al., 'Rights-Based Fisheries Governance: From Fishing Rights to Human Rights: From Fishing Rights to Human Rights', *Fish and Fisheries* 13, no. 1 (March 2012): 14–29, https://doi.org/10.1111/j.1467-2979.2011.00405.x; Micheal N Schmitt and David S. Goddard, 'International Law and the Military Use of Unmanned Maritime Systems', *International Review of the Red Cross, War and Security at Sea* 98, no. 2 (2016): 567–92; David Pinder, 'Seaport Decline and Cultural Heritage Sustainability Issues in the UK Coastal Zone', *Journal of Cultural Heritage* 4, no. 1 (1 January 2003): 35–47, https://doi.org/10.1016/S1296-2074(03)00006-2.

two types of resources (the ocean and terrestrial) on which the global food, supply-chain, trade, manufacturing, production and harvesting depends. Thus, in a broader conception, the Earth system governance or global governance to meet the needs of the people heavily relies on the interconnectivity of the two ecosystems, i.e., marine and terrestrial.[28] The two ecosystems in natural sciences have their own sets of definitions, meanings and explanations, and for marine natural sciences, the main course is the marine environment, biodiversity, ecosystems, and (renewable and non-renewable) energy; the other is ocean resources and for shipping the term referred to as is 'maritime.' Therefore, in political sciences and defence and security studies, the term 'maritime' is used because of its relationship with shipping, which is the primary source providing defence and human-sea interaction beyond nautical borders.[29]

Maritime security and diplomacy as subjects of defence and strategic studies and political science are common interests of the Marine Corps, navies, defence establishments, and strategic think tanks. The recent interests of academia in maritime security and diplomacy have been evident since the South China Sea Arbitration. This arbitration has influenced social scientists primarily due to the future consequences; the *Arctic Sunrise Case*[30] is an excellent example influenced by China's non-participation in the Permanent

[28] Edward H. Allison, 'Big Laws, Small Catches: Global Ocean Governance and the Fisheries Crisis', *Journal of International Development* 13, no. 7 (1 October 2001): 933–50, https://doi.org/10.1002/jid.834; Chiara Armeni, 'Global Experimentalist Governance, International Law and Climate Change Technologies', *International and Comparative Law Quarterly* 64 (2015): 875, https://heinonline.org/HOL/Page?public=true&handle=hein.journals/incolq64&div=56&start_page=875&collection=journals&set_as_cursor=0&men_tab=srchresults; Lucia Fanning and Robin Mahon, 'Governance of the Global Ocean Commons: Hopelessly Fragmented or Fixable?', *Coastal Management* 48, no. 6 (1 November 2020): 527–33, https://doi.org/10.1080/08920753.2020.1803563.

[29] G. Padmaja, 'Modi's Maritime Diplomacy: A Strategic Opportunity', *Maritime Affairs: Journal of the National Maritime Foundation of India* 11, no. 2 (3 July 2015): 25–42, https://doi.org/10.1080/09733159.2015.1112053; Christian Le Mière, *Maritime Diplomacy in the 21st Century: Drivers and Challenges* (London: Routledge, 2014), https://doi.org/10.4324/9780203555590.

[30] Chao Zhang and Yen-Chiang Chang, 'Russian Absence at the Arctic Sunrise Case: A Comparison with the Chinese Position in the South China Sea Arbitration', *Journal of East Asia and International Law* 8 (2015): 413.

Court of Arbitration.[31] This has also appraised the debate on the legitimacy, establishment, and authority and functioning of the Security Council because two permanent members of it arguably do not agree with the jurisdiction of international courts and tribunals.[32] Recurring back to the subject matter behind this vexed issue of law, defence, security, resources and trade routes, the term 'maritime' in the given discourses is relevant and replete.

The first-ever maritime security dispute taken by the International Court of Justice (ICJ), *the Corfu Channel Case,*[33] between the United Kingdom and Albania settled many terms related to maritime security, public international (maritime) law and the law of the sea.[34] It was the landmark case in ICJ as it helped the development of UNCLOS as codified law of the sea in persistence with maritime security provisions during warfare and peacetimes. Furthermore, this case also draws a thin line between private and public-(international) maritime law. ICJ stated that maritime security is not a private issue of any State. Such violations by any State can be adjudicated at international dispute resolution forums. 'Use of force' and the 'law of naval warfare' were the main terms coined by IHL, and this development also supported the establishment and authorisation of the San Remo Manual on International Law Applicable to Armed Conflicts at Sea.[35]

The literature selected from maritime management journals focuses on the governance of ports and shipping. The literature mainly refers to global maritime governance under the auspices of the International Maritime Organization (IMO) and port governance models of different States or the International Association of Ports and Harbours (IAPH).[36] According to its mandate, the IMO is the authority

[31] LI Guoqiang, 'The Origins of the South China Sea Issue', *Journal of Modern Chinese History* 11, no. 1 (2017): 113.
[32] Zhang and Chang, 'Russian Absence at the Arctic Sunrise Case'.
[33] Corfu Channel Case (United Kingdom v. Albania), No. I.C.J. Reports 1949, pp. 244; General List No. 1/15 XII 49 (International Court of Justice 9 April 1949).
[34] Rob McLaughlin, 'Dangerous Waters in International Law: The Corfu Channel Case, Warships and Sovereignty Irritants', in *The ICJ and the Evolution of International Law: The Enduring Impact of the Corfu Channel Case*, ed. Karine Bannelier, Théodore Christakis, and Sarah Heathcote (Routledge, 2012).
[35] McLaughlin.
[36] George S. Reynolds, 'The Regulation of International Shipping : Systematic Issues Facing States in the Administration of Maritime Affairs and the Eradication of Substandard Shipping' (World Maritime University Dissertations, Malmo, Sweden, World Maritime University, 2000), https://commons.wmu.se/cgi/viewcontent.cgi?

regulating international shipping, and the State-parties to it follow its regulations, protocols, and conventions.[37] The primary function of IMO is to monitor, evaluate and report the effective implementation of its conventions by the State-parties. Moreover, IMO proposes shipping-related conventions to the United Nations General Assembly and urges the State-parties to protect the marine environment, seafarers' safety, and maritime labourers' rights. Therefore, the conventions and regimes of IMO are also referred to as 'the maritime regulatory law.'[38]

Another critical element in the sea is 'fishes,' and it is quite pertinent to mention here that most of the disputes settled by the International Tribunal for the Law of the Sea (ITLOS) were entangled with fisheries.[39] The infamous *MV Saiga,* which provided the opportunity of inauguration to ITLOS, was an oil tanker fuelling the fishing vessels in the maritime zone of Guinea.[40] The third and fourth cases in the ITLOS are referred to as the first-ever marine environmental dispute because the *Southern Bluefin Tuna* plays an instrumental role in ocean biodiversity.[41] Furthermore, the fisheries are subject to coastal law and the fishermen, as the coastal communities heavily rely on it. Fisheries as livestock also impact the national economic model, and their regulation and management are subject to local, provincial, and national authorities.[42] Therefore,

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article=1083&context=all_dissertations; 'Assembly Resolutions on the Establishment of a Marine Environment Protection Committee Other Documents: Inter-Governmental Maritime Consultative Organization', *International Legal Materials* 13, no. 2 (1974): 476–81.

[37] International Chamber of Shipping, *ISGOTT: International Safety Guide for Oil Tankers and Terminals*, 5 edition (London: Amer Nautical Services, 2006); Pierre Cariou, 'Is Slow Steaming a Sustainable Means of Reducing CO2 Emissions from Container Shipping?', *Transportation Research Part D: Transport and Environment* 16, no. 3 (2011): 260–64.

[38] Stephan Gollasch et al., 'Critical Review of the IMO International Convention on the Management of Ships' Ballast Water and Sediments', *Harmful Algae* 6, no. 4 (2007): 585–600, https://doi.org/10.1016/j.hal.2006.12.009.

[39] Philippe Gautier, 'The ITLOS Experience in Dispute Resolution', *The Future of Ocean Governance and Capacity Development*, 22 April 2019, 181–88, https://doi.org/10.1163/ 9789004380271_031.

[40] Louise de La Fayette, 'ITLOS and the Saga of the Saiga: Peaceful Settlement of a Law of the Sea Dispute', *The International Journal of Marine and Coastal Law* 15, no. 3 (1 January 2000): 355–92, https://doi.org/10.1163/157180800X00163.

[41] Moritaka Hayashi, 'The Southern Bluefin Tuna Cases: Prescription of Provisional Measures by the International Tribunal for the Law of the Sea', *Tulane Environmental Law Journal* 13, no. 2 (2000): 361–85.

[42] Alan Boyle, 'The Southern Bluefin Tuna Arbitration' 50, no. 2 (2001): 447.

fisheries in the 'maritime' domain connected with the fishing vessels and coastal communities are a vexed subject of law, management, and social sciences.

The literature on policymaking in the 'maritime' domain is somehow confusing because, in governance affairs, the interconnectivity of the issues is crucial. Maritime policymaking, which may be referred to as marine or ocean policy, may also be referred to as shipping policy. The usage of the term 'maritime' in policymaking is the practice of the States in the European Union. It covers broad areas of governance of the seas, including shipping, fish and resources.[43] The European Maritime Policies of the European Economic Area are commonly referred to in literature and are observed as one of the best ocean governance mechanisms in the world. The conventional British approach is slightly different, and the traditional process becomes quite relevant as Pakistan is a standard law system.[44] As in the British system of ocean affairs, maritime, marine and ocean governance are different subjects, and their policy documents deal with them with an interconnected approach.

Based on the above explanations and usage of diverse terminologies related to the 'maritime' domain, table (1) below provides analytical data to observe the usage of the correct terminologies. The data collected for this research is replete with the literature on the 'maritime' domain from diverse perspectives, which provides insightful information on the usage of different terminologies. As it is collected to help Pakistan-based social scientists, this data can be translated into literature, policymaking, legislation, management, and commercial practices, community development, journalism, and campaigns.

[43] Lawrence Juda, 'The European Union and Ocean Use Management: The Marine Strategy and the Maritime Policy', *Ocean Development & International Law* 38, no. 3 (2007): 259–82.

[44] Victor Gekara, 'Understanding Attrition in UK Maritime Education and Training', *Globalisation, Societies and Education* 7, no. 2 (2009): 217–32.

Table 1

Matrix of the Literature Using Various Terminologies in the "Maritime" Domain

Terminology	Discipline/ Subject	Usage	Applicability	References
Maritime	Management	Shipping or Maritime or Ports Management	Management of the Ships, Crew, Port Activities, Cargo, Terminal, Loading, Environment, Customs, etc.	Cariou; Davenport; Couper[45]
		Integrated Coastal Management or Integrated Coastal Zonal Management	Management of Coasts, Coastal Zoning, Coastal Cities Planning, Development and Management	Marea E Hatziolos and Hao Kong and others [46]
	Governance and Public Policy	Ocean Governance and Policy	Ocean Governance for Marine Environment,	Yen-Chiang Chang; Chua; Agarwala[47]

[45] Cariou, 'Is Slow Steaming a Sustainable Means of Reducing CO2 Emissions from Container Shipping?'; Davenport, 'The UNCITRAL Model Law on International Commercial Arbitration'; Couper, 'Environmental Port Management'.

[46] Marea E. Hatziolos, 'A World Bank Framework for ICZM with Special Emphasis on Africa', *Ocean & Coastal Management*, Integrated Coastal Management in Africa, 37, no. 3 (1 January 1997): 281–94, https://doi.org/10.1016/S0964-5691(97)00060-4; Hao Kong et al., 'Towards Integrated Coastal Governance with Chinese Characteristics – A Preliminary Analysis of China's Coastal and Ocean Governance with Special Reference to the ICM Practice in Quanzhou', *Ocean & Coastal Management* 111 (1 July 2015): 34–49, https://doi.org/10.1016/j.ocecoaman.2015.04.008.

[47] Yen-Chiang Chang, 'Good Ocean Governance', *Ocean Yearbook Online* 23, no. 1 (1 January 2009): 89–118, https://doi.org/10.1163/22116001-90000191; Chua, 'Coastal and Ocean Governance in the Seas of East Asia'; Agarwala, 'Role of Policy Framework for Disruptive Technologies in the Maritime Domain'.

			Resources, and Energy. Governance of Land-based sources of pollution.	
		Maritime Policy	Shipping as source of pollution, for example, blast-water management and Emissions.	Agarwala[48]
		(Global) Maritime Governance	Regulation of Ships, IMO Conventions, such as MARPOL, SOLAS, STCW.	Agarwala[49]
	Defence and Strategic Studies	Maritime Diplomacy	Settlement of Inter-state disputes and promotion of usage of territorial seas.	Bateman; Mière[50]
		Maritime Security	Security of Maritime Zones during war and peace times.	Bateman[51]

[48] Agarwala, 'Role of Policy Framework for Disruptive Technologies in the Maritime Domain'.

[49] Gollasch et al., 'Critical Review of the IMO International Convention on the Management of Ships' Ballast Water and Sediments'.

[50] Sam Bateman, 'UNCLOS and Its Limitations as the Foundation for a Regional Maritime Security Regime', *The Korean Journal of Defense Analysis* 19, no. 3 (2007): 27–56; Mière, *Maritime Diplomacy in the 21st Century*.

[51] Bateman, 'UNCLOS and Its Limitations as the Foundation for a Regional Maritime Security Regime'; Salik uddin Ahmed et al., 'China Pakistan Economic Corridor and Pakistan's Energy Security: A Meta-Analytic Review', *Energy Policy* 127 (1 April 2019): 147–54, https://doi.org/10.1016/j.enpol.2018.12.003.

			Piracy and Defense.	
		Maritime Strategy	Strategy of marine corps, navies and other defence establishments.	Juda[52]
	Law	Maritime Law	Wet law, such as, Collision and Salvage, tug and tow, damages and liabilities.	Juda; Allsop[53]
		Shipping Law	Regulatory Maritime Law or Shipping Governance	Gollasch and others[54]
		Admiralty Law	Dry Law, Marine Insurance, Charter parties and Bill of lading.	Staniland[55]
Marine, Seas and Oceans	Public (International) Law and Policy	Oceans Law and Policy	Law for Marine Environmental Protection and Preservation of Ocean	Chang; Akaso; Bateman; Gautier; Bateman; Kong and others[56]

[52] Juda, 'The European Union and Ocean Use Management'.
[53] Juda; Allsop, 'Maritime Law - The Nature and Importance of Its International Character'.
[54] Gollasch et al., 'Critical Review of the IMO International Convention on the Management of Ships' Ballast Water and Sediments'.
[55] Staniland, 'Admiralty Law Legislation'.
[56] Chang, 'Good Ocean Governance'; Akaso, 'Oceans Policy as a Sustainable Tool for the Regulation of the Marine Environment'; Bateman, 'UNCLOS and Its Limitations as the Foundation for a Regional Maritime Security Regime'; Gautier, 'The ITLOS Experience in Dispute Resolution'; Bateman, 'UNCLOS and Its Limitations as the Foundation for a Regional Maritime Security Regime'; Kong et al., 'Towards Integrated Coastal Governance with Chinese Characteristics – A

			Resources.	
		UNCLOS	International Law of the Sea	
		Maritime Dispute Settlement	Negotiations between the States, Arbitral Tribunals (international and regional), International Court of Justice.	
		Maritime Security and Diplomacy	International Humanitarian Law and International Security Protocols	
		Coastal Governance	Governance of Coasts, Coastal Cities and Protection of Coastal Cities Environment.	
	Environment, Ecosystems and Biodiversity	Marine Environmental Protection	Protection of Marine biodiversity, ecosystems, and species.	Chircop[57]
	Energy	Marine Energy	Production of marine renewable	Montserrat Abad Castelos[58]

Preliminary Analysis of China's Coastal and Ocean Governance with Special Reference to the ICM Practice in Quanzhou'.

[57] 'Assembly Resolutions on the Establishment of a Marine Environment Protection Committee Other Documents'; Aldo Chircop, 'Regional Cooperation in Marine Environmental Protection in the South China Sea: A Reflection on New Directions for Marine Conservation', *Ocean Development & International Law* 41, no. 4 (17 November 2010): 334–56, https://doi.org/10.1080/00908320.2010.499300.

			and non-renewable energy.	
	Resources	Preservation and Equitable Utilisation of Ocean Resources	Sustainable Exploitation of Ocean Resources, including, gas and oil mining, or mining of other minerals.	Nathan J Bennett and others [59]
	Fisheries	Fisheries Management and Governance	Management of Fisheries for sustainable management of fish stocks.	Allison[60]

APPLICATION OF THE DEVELOPED FRAMEWORK OF 'MARITIME' TERMINOLOGY IN PAKISTAN

Maritime Law, Governance and Public Policy

In applying the above-established framework to Pakistan, the usage of terminologies in the Merchant Marine Policy of 2001 is a fundamental confusion. It was enacted to incentivise the shipping sector and contain environment-related terminologies in it.[61] As in the framework, the term 'marine' is used for and interconnected with energy, resources and the environment. Thus, a more accurate terminology could be 'shipping policy' or 'merchant shipping policy.' The usage of 'merchant marine' depicts that the United States

[58] Montserrat Abad Castelos, 'Marine Renewable Energies: Opportunities, Law, and Management', *Ocean Development & International Law* 45, no. 2 (3 April 2014): 221–37, https://doi.org/10.1080/00908320.2014.898926.

[59] Nathan J. Bennett et al., 'Coastal and Indigenous Community Access to Marine Resources and the Ocean: A Policy Imperative for Canada', *Marine Policy* 87 (1 January 2018): 186–93, https://doi.org/10.1016/j.marpol.2017.10.023.

[60] Allison, 'Big Laws, Small Catches'.

[61] 'Merchant Shipping Ordinance, 2001' (n.d.)., See also, Aslam Butt, 'National Maritime Policy Approved', *Pakissan*, 21 September 2002, http://pakissan.com/ english/news/2002/ september/national.maritime.policy.approved.shtml.

phenomena of mercantilism have been adopted.[62] United Kingdom as a common law country utilises ‘Shipping Policy’ in relevant documents. Therefore, in hybrid legal and policy systems like Pakistan shall adopt either of the term for further clarity.

Another confusion is the legislation, so-called 'Rules of Business, 1973', which places the 'national maritime policy' under the domain of 'the Ministry of Defence' and its 'Defence Division.'[63] Although the national maritime policy under the Defence Division domain is for ocean zoning, security, and coordination, the fisheries and environmental provisions are ambiguous. The only legislation dealing with marine environmental protection is the Environmental Protection Acts at the Federal level and in the provinces of Sindh and Baluchistan.[64] There are no specific rules or regulations to deal with the marine environment under any other legislation or policy; the 'pollution control boards' of the Port authorities or trusts are almost obsolete.

On the other hand, the Ministry of Maritime Affairs, with the mission and vision of 'continuously developing national ports, providing competitive shipping, enhancing seaborne trade, harnessing marine fishing resources and developing coastal infrastructure contributing towards the prosperity of the country,' is also confused about their domain and authorities.[65] As coastal development is a provincial or municipal subject, fisheries have their own governing authorities. Although the Korangi Fisheries Harbour Authority and Marine Fisheries Research Laboratory Karachi are loosely under the Ministry of Maritime Affairs domain, the unregulated fishing sector of

[62] ‘United States Merchant Marine Policy and Surplus Ships on JSTOR’, accessed 11 August 2021, https://www.jstor.org/stable/1825744.

[63] Pakistan and Cabinet Division, *Rules of Business (As Amended up to 3rd March 2017)* (Islamabad, Pakistan: Government of Pakistan, http://cabinet.gov.pk/cabinet/userfiles1/file/ROB-amended-03-03-2017.pdf, n.d.), http://cabinet.gov.pk/cabinet/userfiles1/file/ROB-amended-03-03-2017.pdf.

[64] M Jahanzeb Butt, Yen Chiang Chang, and Khadija Zulfiqar, ‘A Comparative Analysis of the Environmental Policies in China and Pakistan: Developing a Legal Regime for Sustainable China-Pakistan Economic Corridor (CPEC) under the Belt and Road Initiative (BRI)’, *IPRI Journal*, IPRI Journal, 21, no. 01 (June 2021): 83–122, https://doi.org/10.31945/iprij.210104.

[65] Panneerselvam, ‘Maritime Component of China–Pakistan Economic Corridor (CPEC)’.

Pakistan is an ostensible issue for governing authorities.[66] Moreover, the oceanography and hydrological research under the auspices of the Marine Biological Research Laboratory in Karachi is significantly placed under the Ministry; its research publications and literature development are questionable.

Blue Economy and Inter-coordination of Various Authorities

As oceans increasingly become crucial in enabling and linking the regulatory and economic perspective, and the relationship between land and marine ecosystems evolves, the role and concept of 'Blue Economic' have gained momentum.[67] 'Blue Economy' as a concept is a structure of various types of activities that are associated with ocean services and focuses on sustainable economic growth, livelihood improvement, and creating green jobs by equitably utilising ocean resources while preserving and protecting the marine ecosystems. This concept, therefore, requires a primary national-based agenda and policy with enlarged stakeholder engagement. It will be a hefty exercise for the responsible authorities, and there is no other solution. This calls for an inter-coordination mechanism among and between environmental, climate, maritime, defence and economic regulatory authorities in devising a policy for future development in the 'maritime' domain.[68]

Literature Development

As has already been discussed, the scarce literature in the 'maritime' domain by Pakistan-based scholars in foreign journals has followed the usage of accurate terminologies, and the local literature is perplexing.[69] One of the blogs on 'maritime study' has specified the

[66] Books LLC and General Books LLC, *Ports and Harbours of Pakistan: Port Qasim, Gwadar Port, Gadani Ship-Breaking Yard, Minnagara, Barbarikon, Oraea, Karachi Fish Harbour* (General Books LLC, 2010).

[67] Meg R. Keen, Anne-Maree Schwarz, and Lysa Wini-Simeon, 'Towards Defining the Blue Economy: Practical Lessons from Pacific Ocean Governance', *Marine Policy* 88 (1 February 2018): 333–41, https://doi.org/10.1016/j.marpol.2017.03.002.

[68] Nathan James Bennett et al., 'Blue Growth and Blue Justice: Ten Risks and Solutions for the Ocean Economy', *Marine Policy* 125 (1 March 2021): 104387, https://doi.org/ 10.1016/j.marpol.2020.104387.

[69] See for example, Yen-Chiang Chang et al., 'Legal Practices and Challenges in Addressing Climate Change and Its Impact on the Oceans—A Chinese Perspective', *Marine Policy* 111 (1 January 2020): 103355, https://doi.org/10.1016/j.marpol.2018.11.018; Muslim Bin Aqeel, 'Maritime Environment and Oil Spillage: Legality and Regimes', *Maritime Study Forum* (blog), 9 November 2020,

'maritime environment' and 'marine environment' as the same ecosystems; the terminologies related to ocean affairs in shipping, fisheries and marine resources are vexed with each other, and the explanation is complex.[70] Moreover, due to weak accountability and transparency, the literature available online on 'maritime' from Pakistan-based journals suggests that Gwadar is the only subject to it.

Although the maritime domain is complex, its study and relevant literature make it clear and unambiguous. Settling the future research direction in the 'maritime' arena is essential, and its ignorance may form additional sets of complexities. The given framework may be proven significant based on the development of maritime, marine and ocean policies in which academic literature can play a critical role. There are going to be challenges to the interpretation of legislation and policies. Specifically, in the 'maritime' domain, the issues are countless, and international and recognised literature is useful for the future development of literature in any domain related to 'maritime.'

THE FUTURE OF MARITIME IN THE ERA OF ANTHROPOCENE

This is an era of the 'Anthropocene.'[71] In this interdependent and globalised world, the United Nations recently forwarded Agenda – 2030 (also known as Agenda – Post-2015) or Sustainable Development Goals (SDGs).[72] One of the crucial components of SDGs related to the 'maritime' domain is Goal – 14 (Life Below Water); it has ten targets and indicators for sustainable development of the oceans as well as protection, preservation and restoration of marine

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https://www.maritimestudyforum.org/maritime-environment-and-oil-spillage-legality-and-regimes/.

[70] Kayani, 'THE OCEAN Life, Livelihood and Sustainability Opportunities and Challenges for Pakistan'; Aqeel, 'Maritime Environment and Oil Spillage'.

[71] Relating to or denoting the current geological age, viewed as the period during which human activity has been the dominant influence on climate and the environment, please see: Elham Seyedsayamdost, 'Global Governance in the Age of the Anthropocene: Are Sustainable Development Goals the Answer?', *Global Environmental Politics* 19, no. 2 (24 April 2019): 169–74, https://doi.org/10.1162/glep_a_00509.

[72] 'Final List of Proposed Sustainable Development Goal Indicators', Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators, 2016, https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf; M. Jahanzeb Butt, 'The Role of the International Law in Shaping the Governance for Sustainable Development Goals', *Journal of Law and Political Sciences* 28 (2021).

and coastal ecosystems, including sustainable fisheries and equitable utilisation of oceans resources.[73] Goal – 14 is related to all the other 17 SDGs as it is impacted by or impacts them; taking Goal – 1 (No Poverty) and Goal – 2 (Zero Hunger) as examples, both are connected with international trade and its key component shipping as well as fisheries and ocean resources.[74]

On the other hand, the climate crisis (Climate Action is Goal – 13 of the SDGs) has brought deep interests of the global academia towards environmental action, and oceans are its main ingredient.[75] Oceans, covering 71% of the earth's surface, are critical ecosystems being impacted by climate change in acidification, sea-level rise, and coastal flood risk. Therefore, recently the IMO has attempted to regularise carbon emissions through its Sulphur 2020 and GHG Emissions Regulations.[76] IMO also acknowledges that the future of global shipping shall be sustainable, and interconnectivity is unavoidable.

Similarly, according to its mandate, the United Nations Division on the Ocean and Law of the Sea Affairs (UNDOALAS) has also recognised the sustainability of oceans.[77] As UNDOALAS is responsible for the sustainable exploitation of oceans and monitoring maritime dispute resolution, it has called the State-parties to UNCLOS to resolve the disputes for equitable utilisation of ocean resources

[73] M. Jahanzeb Butt, Khadija Zulfiqar, and Yen-Chiang Chang, 'The Belt and Road Initiative and the Law of the Sea, Edited by Keyuan Zou', *The International Journal of Marine and Coastal Law* 1, no. aop (2021): 1–4, https://doi.org/10.1163/ 15718085-BJA10051; Islam and Shamsuddoha, 'Coastal and Marine Conservation Strategy for Bangladesh in the Context of Achieving Blue Growth and Sustainable Development Goals (SDGs)'.

[74] Roland Cormier and Michael Elliott, 'SMART Marine Goals, Targets and Management – Is SDG 14 Operational or Aspirational, Is "Life Below Water" Sinking or Swimming?', *Marine Pollution Bulletin* 123, no. 1 (15 October 2017): 14, https://doi.org/10.1016/ j.marpolbul.2017.07.060.

[75] Chang et al., 'Legal Practices and Challenges in Addressing Climate Change and Its Impact on the Oceans—A Chinese Perspective'.

[76] G. Robbert Biesbroek et al., 'Europe Adapts to Climate Change: Comparing National Adaptation Strategies', *Global Environmental Change* 20, no. 3 (August 2010): 440–50, https://doi.org/10.1016/j.gloenvcha.2010.03.005.

[77] Akaso, 'Oceans Policy as a Sustainable Tool for the Regulation of the Marine Environment'.

amicably.[78] Furthermore, the United Nations Environment Programme, with 18 regional and sub-regional seas programmes, also recognises Goal – 14 and has urged State-parties to marine environmental conventions to control, mitigate and effectively regulate land-based marine pollution.[79]

The main purpose of mentioning the developments under the United Nations agenda is to attain Pakistan's academic circles' focus on Goal – 14 and its related contents under the 'maritime' domain. The literature development related to SDGs on the one hand and Goal – 14 on the other is quite scarce by Pakistan-based academia. Moreover, in understanding the 960 kilometres of coastal line, along with the coastal zone and differentiating it with the ports, Pakistan is part of the global marine ecosystem. Regarding fisheries, international trade and port development, Pakistan will be one of the key players in Eurasia in the 'maritime' domain. Therefore, Pakistan is pivotal in playing its part in oceans, shipping and fisheries sustainability and restoration of marine ecosystems.

ARTIFICIAL INTELLIGENCE AND AUTONOMY IN MARITIME SYSTEMS

Another challenging aspect in the maritime domain is the use of artificial intelligence in shipping, autonomous maritime systems for oceanography, surveillance, marine biological research, defence, and attack.[80] These systems are multifariously referred to in the literature, such as autonomous maritime systems, ships, and vessels. [81] However, IMO's analogy is quite persistent following its mandate,

[78] Robert Beckman, 'International Law, UNCLOS and the South China Sea', in *Beyond Territorial Disputes in the South China Sea* (Edward Elgar Publishing, 2013), 47–90.

[79] U. N. Environment, 'Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities', *UNEP - UN Environment Programme* (blog), 30 August 2017, http://www.unep.org/resources/toolkits-manuals-and-guides/global-programme-action-protection-marine-environment-land.

[80] Schmitt and Goddard, 'International Law and the Military Use of Unmanned Maritime Systems'; Kara Chadwick, 'Unmanned Maritime Systems Will Shape the Future of Naval Operations: Is International Law Ready?', in *Maritime Security and the Law of the Sea, Help or Hindrance*, ed. Malcolm D. Evans and Sofia Galani, 1st ed., vol. 1 (United Kingdom: Edward Elgar Publishing, 2020), 132–56.

[81] Yen-Chiang Chang, Chao Zhang, and Nannan Wang, 'The International Legal Status of the Unmanned Maritime Vehicles', *Marine Policy* 113 (2020): 1.

which is limited to the sea's surface.[82] Thus, IMO calls Maritime Autonomous Surface Ships, which could be employed by the crew or could be fully autonomous or partially autonomous with the crew on board.[83] On the other hand, the prominent organisation dealing with defence and security, the International Committee of Red Cross, refers to the weapons and surveillance systems as 'Unmanned Maritime Systems' and specifies them as 'Unmanned Surface Vehicles' and 'Unmanned Underwater Vehicles.'[84]

However, in Pakistan, any such policy to designate any autonomous system is still in vain. This is perhaps one reason for the relative paucity of literature development related to the subject matter in Pakistan. Moreover, there is quite a weak system of coordination among and between academia and defence and security establishments, which has caused additional sets of problems in relevant literature in the 'maritime' domain. This possibly is a subject of defence policy and requires serious attention to prevent further control of Pakistan's maritime autonomous systems and foreign ones.

China-Pakistan Economic Corridor and Future Development of the Policy and Literature

Based on the above discussion, literature review, and theoretical and conceptual framework, the existing literature could be enriched, and the future development of literature in the 'maritime' domain by Pakistan-based academics and relevant authorities could be presented in a better format by using of correct terminologies. The most critical is the CPEC and the literature in its maritime domain because it will shape Pakistan's future policy.[85] As part of the BRI, CPEC is most significant for China in terms of international trade and strategy in its own 'maritime' domain. Therefore, recent interests of

[82] Michael Baldauf et al., 'E-Navigation, Digitalization and Unmanned Ships: Challenges for Future Maritime Education and Training' (12th International Technology, Education and Development Conference, Valencia, Spain, 2018), 9525–30, https://doi.org/10.21125/ inted.2018.2374.

[83] Massimo Caccia et al., 'Basic Navigation, Guidance and Control of an Unmanned Surface Vehicle', *Autonomous Robots* 25, no. 4 (2008): 349–65.

[84] Peter Asaro, 'On Banning Autonomous Weapon Systems: Human Rights, Automation, and the Dehumanization of Lethal Decision-Making', *International Review of the Red Cross* 94, no. 886 (June 2012): 687–709, https://doi.org/10.1017/S1816383112000768.

[85] Baldauf Et Al., 'E-Navigation, Digitalization and Unmanned Ships'.

China-based academics in BRI and CPEC are evident.[86] There are prospective discussions on marine environmental protection, maritime security, international trade, and collaboration between Chinese and Pakistani authorities in the different 'maritime' domains.[87]

Flawed application of the term 'maritime' in CPEC Discussion has resulted in misunderstandings in public conversation.[88] While examining media accounts, official declarations, and scholarly works, the research highlighted the specific cases where the term 'maritime' has been erroneously employed in relation to the CPEC. Therefore, an analysis of political rhetoric and its impact on the incorrect usage of the term "maritime" through this paper has provided a right context for its usage in the context of CPEC.[89]

The preceding discussion explored the improper utilisation of the term 'maritime' in the discourse pertaining to the CPEC. More precisely, the article examined two crucial elements: a) Inaccuracies in public discussions, including media coverage, public comments, and scholarly publications, and b) Political language, analysing how political discussions lead to the incorrect use of the term in relation to the CPEC.[90]

CPEC has garnered significant interest in Pakistan, but the application of the term 'maritime' to describe this primarily land-based initiative has frequently been incorrect. The research examined headlines, articles, and expert opinions to identify trends and patterns contributing to these fallacies.[91] This section intends to analyse the misuse of the term 'maritime' in the discourse around the CPEC by examining public statements made by officials, experts, and stakeholders. A comprehensive examination of scholarly literature,

[86] Chang, Zhang, and Wang, 'The International Legal Status of the Unmanned Maritime Vehicles'.

[87] See for example, Yen-Chiang Chang and Mehran Idris Khan, 'China–Pakistan Economic Corridor and Maritime Security Collaboration: A Growing Bilateral Interests', *Maritime Business Review* 4, no. 2 (1 January 2019): 217–35, https://doi.org/10.1108/MABR-01-2019-0004.

[88] Gekara, 'Understanding Attrition in UK Maritime Education and Training'.

[89] Safdar, 'The China-Pakistan Economic Corridor – Its Maritime Dimension and Pakistan Navy'.

[90] Chang and Khan, 'China–Pakistan Economic Corridor and Maritime Security Collaboration'.

[91] Panneerselvam, 'Maritime Component of China–Pakistan Economic Corridor (CPEC)'.

encompassing research papers and academic publications, is undertaken to detect any occasions where the term 'maritime' is inaccurately used in relation to the CPEC.

Examining the wider consequences of the improper application of the term 'maritime' in CPEC debates it highlights the inaccurate usage of the term 'maritime' in relation to the China-Pakistan Economic Corridor.[92] The research thoroughly investigated the elements that contribute to this misapplication by examining media reports, public remarks, scholarly works, and political rhetoric. Acknowledging the consequences of these misconceptions is essential to promote a more precise comprehension of the CPEC and guarantee well-informed public discussions and policy formulation.[93]

Conversely, in Pakistan, due to the relative paucity of literature development and the slow process of access to information, the academic circles are still uncertain regarding the diversity of CPEC and BRI.[94] However, the OBOR was converted to BRI long ago due to the strategic vision of the terminology. Such modification by Chinese authorities also represents the significance of using accurate terminology in the international arena, more precisely in the United Nations and other international organisations.[95]

The port of Gwadar's framework is already questionable, and its future development requires a significant shift to match it with Goal – 14[96] as well as with artificially intelligent systems. Moreover, the shipping policy, marine environmental protection law, and maritime defence and security programmes require sheer attention and revision under the CPEC regime and Pakistan's shift in international relations. In this, the role of academia becomes quite relevant and significant, and there must be positive coordination among the relevant

[92] Panneerselvam.
[93] Reynolds, 'The Regulation of International Shipping : Systematic Issues Facing States in the Administration of Maritime Affairs and the Eradication of Substandard Shipping'.
[94] See for example, Prof Dr Muhammad Iqbal Chawla, 'One Belt One Road Summit 2017 and Its Implications for CPEC: An Overview*', *South Asian Studies* 32, no. 2 (24 September 2020), http://111.68.103.26/journals/index.php/IJSAS/article/view/3109.
[95] Padmaja, 'Modi's Maritime Diplomacy'.
[96] Butt, Chang, and Zulfiqar, 'A Comparative Analysis of the Environmental Policies in China and Pakistan'.

stakeholders with academia in the development of future CPEC maritime policy.

Conclusion

Pakistan possesses the capacity to transform into a marine nation through the establishment of new ports and the facilitation of communication within and between various regions. The academic community in Pakistan has the potential to significantly contribute to the advancement of literature in the field of maritime studies. Acquiring expertise in the 'maritime' field necessitates extensive research conducted by both established and newly founded research centers, think tanks, and academic institutions. While the field of 'maritime' studies is relatively new in Pakistani academia, its presence in literature dates back to the inception of Pakistan. Furthermore, the available global literature, policies, and programs in the field of 'maritime' can assist academia in Pakistan in developing literature that aligns with the correct direction.

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Analysis of Karachi Coast Through Geo Spatial Technique from 2013-2022

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Abstract

Climate change is a burning issue at present time. The Intergovernmental Panel on Climate Change (IPCC) estimates global mean sea levels to upsurge from 0.43 m to 0.84 m by the 21st century's end. In the world, Pakistan is more likely to experience coastal hazards due to uncertain hydrodynamics in the Arabian Sea. Coastline erosion is one of the phenomena which are directly linked with increase in sea level rise.

Karachi coastline has been delineated by the action of waves, winds, currents and tides which are the consequences of sea level rise causing immense shoreline changes. Remote Sensing techniques play a crucial role in spatio-temporal analysis. In this study, medium spatial resolution of 30m multi sensor Landsat images from 2013-2022 along the 100m coast of Karachi are providing data. For the estimation of changing coast line, a digital shoreline analysis system (DSAS) tool is utilized. From Cape Monz to Hawksbay in western coast, the rate of erosion and deposition are not indicating an alarming situation. It means anthropogenic activities are negligible in these areas. In contrast, eastern coast of Karachi like Keemari, Korangi and Port Qasim show an imbalance of sediment budget.South of Karachi depicted high accretion. In DSAS technique, out of 567 transects, 41% reported as erosional while 58% are accretional.

This research will not only assist in providing data for coastal engineering but also recognition of coastal vegetation in order to maintain marine habitat .and minimize the incident and intensity of the catastrophic hazards.

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Key words: Remote sensing, erosion, accretion, hydrodynamics, DSAS Tool, shoreline change, Landsat, Anthropogenic activities.

1. Introduction

Coastal zones and shorelines are very dynamic in nature. Anthropogenic activities coupled with global warming intensify tide level, wave height and sea level which will result in morphological shoreline changes. The Intergovernmental Panel on Climate Change (IPCC) estimates global mean sea levels to upsurge from 0.43 m to 0.84 m by the 21st century's end. The shape and location of the shoreline, which separates land from the sea, are always changing depending on the surroundings. Due to the Arabian Sea's coastal and riverine processes, this coastal region is subject to waves and tides brought on by the monsoon season.[1]

Pakistan is ranked seventh in terms of vulnerability to climate change-related occurrences. Four severe floods and six previous cyclones have harmed the socio-economics of low-lying communities in the Sindh coastline region.[2] Coastal zones are commonly thought to be permanent and stable characteristics, however the truth is that shorelines are very dynamic in nature and susceptible to anthropogenic and natural processes. Global climate change phenomena such as sea level rise are also important in inducing mid- and long-term changes in coastal areas (IPCC 2007). Coastal vulnerability assessments continue to emphasize primarily on rise of sea level, with monitoring of historical shorelines serving as an important criterion for the assessment (IPCC 2007). The coastal belt of region of Indus Delta is constantly evolving due to natural phenomena like tidal action, waves, wind speed, rising sea level, and anthropogenic issues such as pollution,

[1] Afsar, S., Masood, H., & Bano, S., "Monitoring of the shoreline change and its impact on mangroves using remote sensing and GIS: a case study of Karachi coast, Pakistan" (International Journal of Biology and Biotechnology 10, no. 2, 2013): 237-246.

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for example land encroachment near shoreline and alteration.[3] [4] [5]

There are methods available to inquire coastal changes like survey of topo graphics, aerial Photogrammetry, unmanned aerial systems (UAS), and global positioning system (GPS) surveys.[6]

It's excellent to see that various researches have been done in different regions, including Bangladesh, Egypt, the Mediterranean Sea, the Delta of Yellow River, and the Delta of Pearl River in China, to understand coastline changes. While there has been substantial research in these areas, it's also notable that specific attention has been given to the Delta of Indus River's region (IDR) in Pakistan. Coastal infrastructure, such as ports, roads, and settlements, is at risk from shoreline changes.[7] Coastal changes, especially those associated with sea-level rise and erosion, can lead to the intrusion of saltwater into freshwater sources. This poses a threat to drinking water supplies, agricultural irrigation, and overall water quality.[8] The research by authors [9] addressed about the vulnerability of the deltaic creek system, especially near Karachi.

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The vulnerability of twenty million people and forty percent of Pakistan's industry to the effects of coastal erosion is a significant concern. Coastal erosion can have wide-ranging impacts on both human communities and economic activities. Understanding the dynamics of coastline changes provides essential information for planning and implementing adaptation strategies. This may include the construction of protective structures, land-use planning, and the development of early warning systems for coastal communities.[10] This research contributes to the broader understanding of the complex interactions between sea level rise and coastal dynamics particularly erosional activities in Karachi. Also attention is given about reduction of Mangroves within in ten years only.

2. Aims and Adjectives

- To give awareness about sustainable environment in order to advance coastal engineering.
- To determine an area engulfed by shoreline delineation through map using DSAS in GIS.
- To illustrate the relationship between rising sea level and coastal hazards in Karachi coast.
- To evaluate the reduction in mangroves
- To highlight the importance of mangrove forests in preventing coastal hazards.

3. Study Area

Karachi is one of the mega city of Pakistan, housing about 7% of its population. Karachi is located in Southern Pakistan in the north of Arabian Sea .67º00’36” east longitudes and 24º51’36” north latitude comprising 3,527 sq. km. physically it is mostly comprises flat, lies in Sindh coast and is operational as a harbor for last 125 years.

[10] Waqas, M., Nazeer, M., Shahzad, M., Zia, I., "Spatial and Temporal Variability of Open-Ocean Barrier Islands along the Indus Delta Region," Remote Sens. 11 (2019): 437.

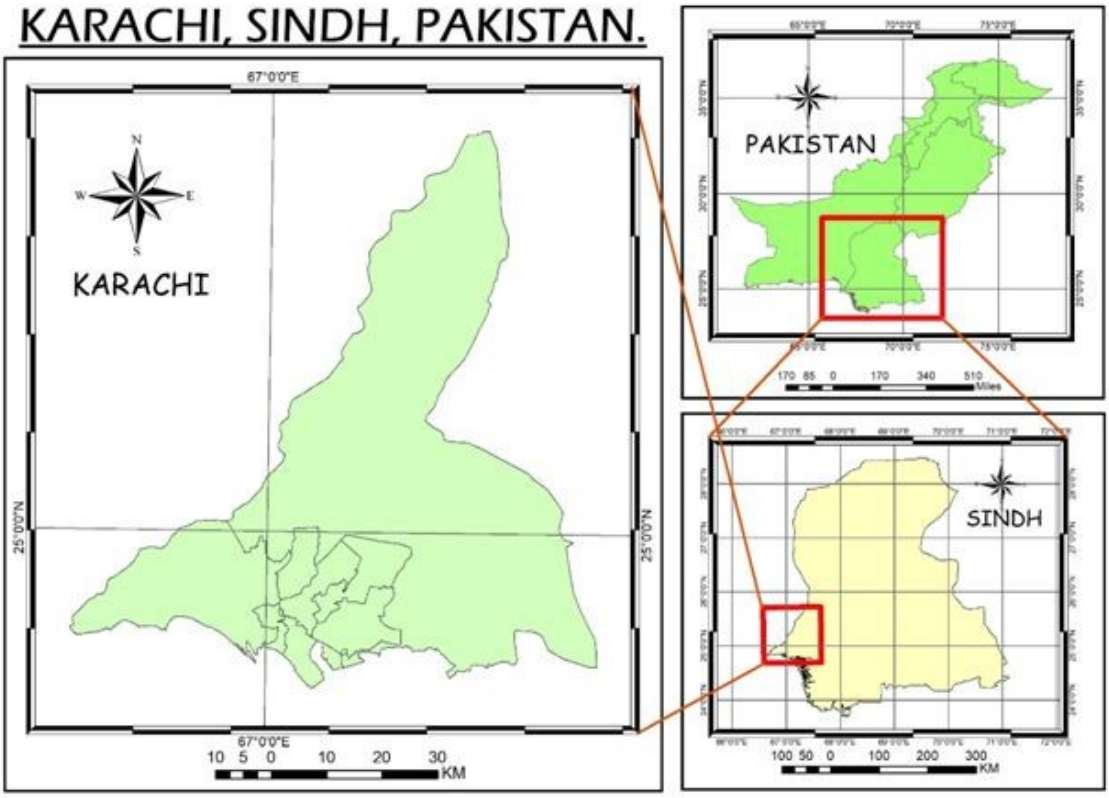

Figure 1 Study area along coast of Karachi, sea surface temperature varies from 24C-28C in summer and from 20C-24C in winter.

4. Importance of Study Area

The Karachi's coast Fig (1) is nearly 100 km between the Gharo creek on the east and the hub of river on the west. It is contemplated as financial center for Pakistan as 90% of maritime trade is accomplished through the Port of Karachi and the Port Qasim. Raised beaches with moderate climate and marine terraces are present along the coast which are 6m to 15m above sea level. The Malir and Lyari River passes through the city.

5. Methodology

Integrating these methods like topographic survey, unmanned aerial system, global positioning system GPS often provides a comprehensive understanding of coastal changes. Researchers and environmental managers can choose the most suitable combination based on the specific goals, budget constraints, and the scale of the study area.

Addressing the financial and labor challenges associated with coastal assessments in developing countries requires a multi-faceted approach, combining technological innovation, capacity building, and international cooperation. Image got from Google Earth Engine, Land Sat_7 down loaded for the month of May in 2013.We chose only free of cloud and climatically accurate 30-m Landsat (TM: Thematic Mapper). Image was not clear 2012 May, that's why Land Sat 7 took under observations.

Image down loaded from United States Geological Survey USGS) Earth Explorer of Land sat _8 and Land sat_9 respectively for the years of 2013 and 2022 in May.

Mosaicing needed for digitization of shore line and base line for both images. 2012& 2022 of May. The tool of Digital Shoreline Analysis System (DSAS) was developed by the U.S. Geological Survey (USGS) under the Coastal and Marine Geology Program. DSAS is designed to analyze shoreline changes using digital data and is often used in conjunction with GIS (Geographic Information System) software like ArcGIS. [11] DSAS employs statistical algorithms to analyze the changes in the shoreline position over time. Common statistical measures include End Point Rate (EPR) The average rate of change between the oldest and most recent shorelines. Net Shoreline Movement (NSM): The algebraic sum of the distances the shoreline has moved landward or seaward. It considers both positive and negative values, indicating whether the shoreline is advancing or retreating.[12] [13]

Shoreline positions extracted from historical topographic sheets and multi-temporal photos are entered into the geodatabase. Each entry includes relevant attributes such as date, shape length, cast direction, and any other information deemed important for the analysis. Positive (+) and negative (-) values are assigned to the

[11] Kuleli, T., Guneroglu, A., Karsli, F., & Dihkan, M. (2011). Automatic detection of shoreline change on coastal Ramsar wetlands of Turkey. Ocean Engineering, 38(10), 1141-1149.

[12] Kuleli, T., Guneroglu, A., Karsli, F., & Dihkan, M. (2011). Automatic detection of shoreline change on coastal Ramsar wetlands of Turkey. Ocean Engineering, 38(10), 1141-1149.

[13] Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., Ergul, A., "The Digital Shoreline Analysis System (DSAS) Version 4.0 - An ArcGIS Extension for Calculating Shoreline Change," U.S. Geological Survey: Reston, VA, USA, 2009

transects based on the direction of shoreline movement. Inward movement is denoted by positive value and landward movement is represented by negative value. This directional information is crucial for interpreting and understanding the dynamics of shoreline changes.[14] The metrics —NSM, SCE, EPR, LMS, and LRR—are commonly used in shoreline change analysis to quantify different aspects of coastal dynamics.[15] But in this paper we will discuss the NSM and EPR only. The EPR was used to estimate the rate of erosion and accretion per year at each transect, while NSM elaborated about the movement of shore line.

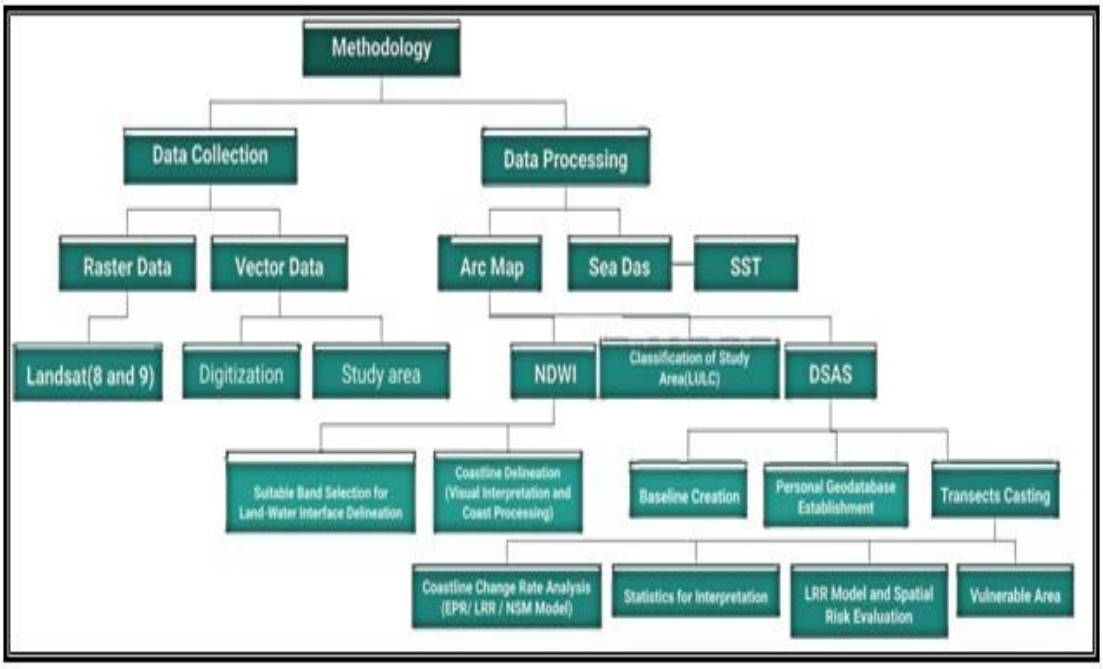

Figure 2 Methodology

[14] Kuleli, T., Guneroglu, A., Karsli, F., & Dihkan, M. (2011). Automatic detection of shoreline change on coastal Ramsar wetlands of Turkey. Ocean Engineering, 38(10), 1141-1149.

[15] Ozturk, D., & Sesli, F. A. (2015). Shoreline change analysis of the Kizilirmak Lagoon Series. Ocean & Coastal Management, 118, 290-308.

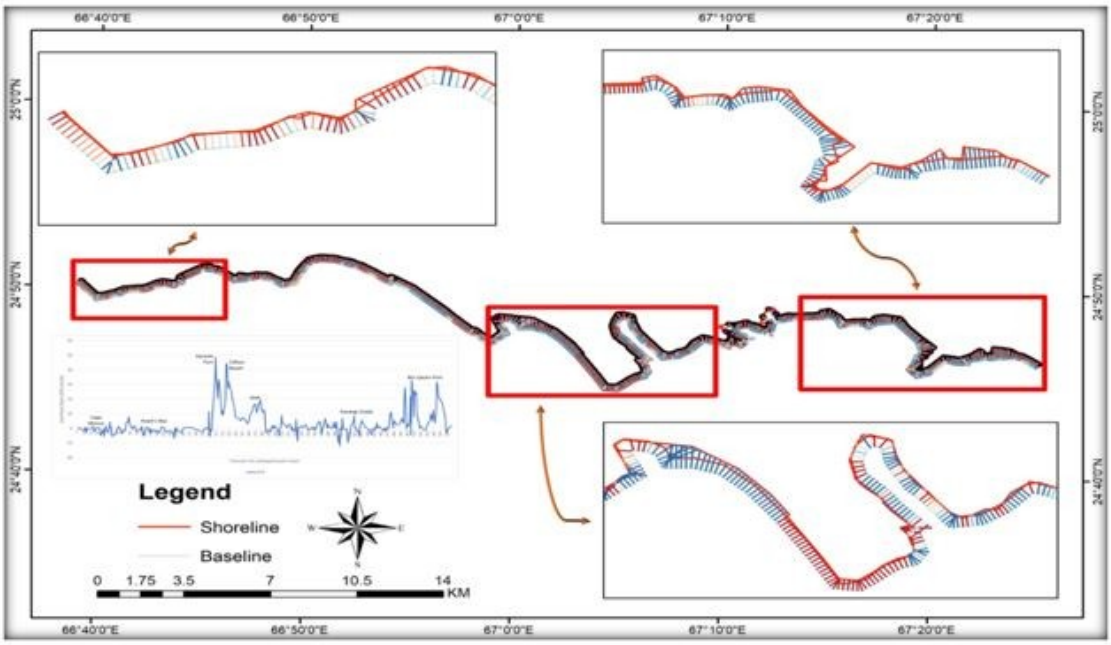

Figure 3 Digital Shoreline Analysis System

6. Result and Discussion

The usual consequences of rising sea level comprise of the inundation of low-lying areas, erosion of beaches, intrusion of sea water into creek area and surface waters, and amplified flooding and storm damages. [16]

It's important to note that coastal environments are subject to natural processes, including erosion, sedimentation, and changes in sea level. Understanding the geological and geomorphological features of the Karachi coastline is crucial for sustainable coastal management, especially in a highly urbanized and developed area where human activities may impact the natural coastal dynamics. The observation of coastline oscillation between erosion and accretion in the Karachi zone indicates the dynamic nature of coastal processes in this region. Coastal changes are affected by certain factors like physical processes, anthropogenic activities, and environmental conditions. The mention of subzones within Karachi, specifically Karachi South, Karachi West, and Karachi East.

[16] Nicholls, R. J., & Leatherman, S. P. (1995). Global sea-level rise. 92-123p. Strezepek and Smith.

In summary, the use of Landsat TM and OLI satellite imagery to observe and analyze changes in land accretion in the Karachi South subzone underscores the significant retreat. According to Digital Shoreline Analysis System (DSAS) assessed the rate of systematic land loss and/or gain due to natural processes and human activities along the coastline. Here we found the rate of erosion by using EPR and NSM only. There are 556 transects Fig (3) are showing erosion and accretion. Out of 556, 231 are erosional transects while 325 transects showed accretion. It means 58.45% are not affected by erosion.

In western side of sandy beaches, sediment budget is stable and followed up the findings of author[17] also.

Transect 210 showed highest accretion of about 48m land retreat in Kemari which is composed of loosed stone.

At Clifton beach (composed of tidal flat sand), 45m of land showed accretion on 221 transect ID. In DHA, 20m of land is reclaimed on transect 260-290 which is the highest accretion rate at the transects along the subzone Karachi South coastline, which is a potential result of coastal reclamation Erosional activities in external side of islands are highlighted in Gizri and Korangi Creek on transect 395-411. These observations are also parallel with author [18] which depicted about the erosion of barrier islands near Karachi during 1974-2017.

Every year, along the coast of Karachi, -1.91 of land shows erosion and 7.14m of land shows accretion during a decade. The phenomenon of erosion allowed the sea water intrusion near shore and caused depletion of coastal vegetation.

[17] Kanwal, S., Ding, X., Sajjad, M., & Abbas, S. "Three Decades of Coastal Changes in Sindh, Pakistan (1989–2018): A Geospatial Assessment." Remote Sensing 12, no. 1 (2020): 8.

[18] Waqas, M., Nazeer, M., Shahzad, M., Zia, I., "Spatial and Temporal Variability of Open-Ocean Barrier Islands along the Indus Delta Region," Remote Sens. 11 (2019): 437.

7. Effects of Coastal Erosion

Mangroves are appeared in Chinna creek, entrance of Karachi port trust and also present in Gharo of port Qasim. In southern side Ghizri and eastern Karachi comprised of mangroves also.

From 2013-2022, increase in built up noticed as 3 percent from the image of land sat ,but the quick reduction in mangroves is alarming as 9 percent within ten years.

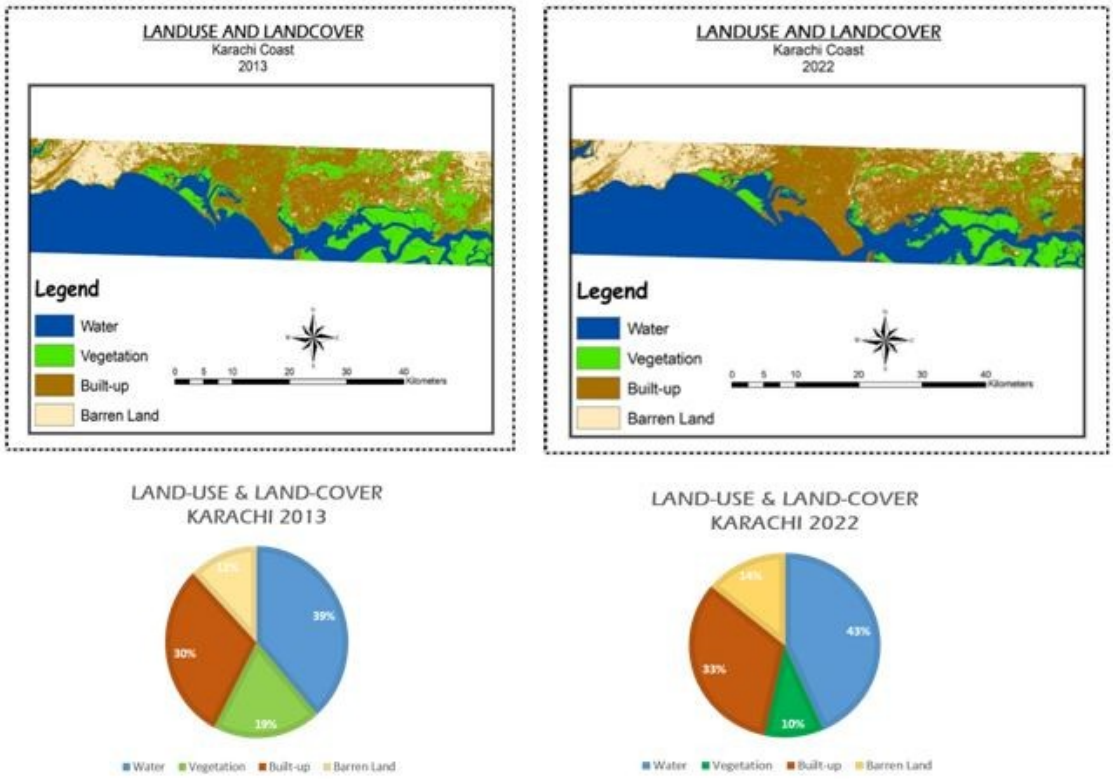

Figure 4 Patches of barren land are filled by built up due to increase in anthropogenic activities. Another important point is that gap between coast line and water has increased. This is the indication of sea water encroachment.

8. Outcomes of Erosion

Major coastal hazard, erosion endangers millions of people and coastal infrastructure near shore. Coastal delineation occurred and production of natural vegetation like mangroves decreased. Fishing activity reduced due to loss in marine habitat.

9. Measures

We stress that the coastal infrastructure should be planned with special care. Stabilization of coastline demands scientific seeding techniques for reforestation of mangroves and preservation of the remaining.

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Tackling the Menace of Illegal, Unreported, and Unregulated Fishing: A Call for Global Action

Ghazi Salahuddin*

1. Introduction

Illegal, Unreported, and Unregulated (IUU) fishing presents a complex challenge with widespread impacts on the economy, society, and environment. In the realm of fisheries management, IUU activities intensify issues, particularly affecting vulnerable developing nations[1]. This article explores the profound consequences of IUU fishing across economic, social, and environmental dimensions. It also draws attention to the interconnected rise of piracy in the Horn of Africa. The global term "IUU fishing" denotes non-compliance with fisheries conservation obligations, affecting both developing and developed nations. Even well-resourced countries like the U.S. face difficulties combating IUU fishing, as seen along its border with Mexico due to the demand for shark fins[2].

2. Economic Impacts

The economic fallout of IUU fishing is staggering, with repercussions at both macro and micro levels. The cycle of illegal fishing, from small-scale operations to industrial levels, disrupts processes such as shipment, processing, and distribution[3]. Legitimate operators face losses in revenue, levies, and taxes, as IUU fishers displace them. The disruption of markets leads to negative adjustments in fishing quotas, affecting law-abiding operators. Globally, estimates by David Agnew indicate annual losses ranging

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[1] Marine resources assesment group. (2005). Review of Impacts of Illegal, Unreported and Unregulated Fishing on Developing Countries (pp. 55- 70, Rep.). London: Marine resources assesment group.

[2] S. H. (2014). Too big to tackle? The persistent problem of pirate fishing and the new focus on port state measures. Retrieved August 6, 2015, from https://litigationessentials. lexisnexis.com/webcd/app?action=DocumentDisplay&crawlid=1&doctype=cite&docid=37+Suffolk+Transnat%27l+L.+Rev.+109&srctype=smi&srcid=3B15&key=a1ec4cf66ed185246791817eaf9e1c14.

[3] Liddick, D. (2014, December). The dimensions of a transnational crime problem: The case of IUU fishing. Trends in Organized Crime, 17(4), 290-312.doi:10.1007/s12117-014-9228-6

from $10 billion to $23.5 billion, underlining the severe economic toll of IUU fishing, especially on developing nations[4].

3. Social Impacts

IUU fishing contributes significantly to hunger and poverty in regions where fish is a primary protein source. The social consequences extend to armed resistance against surveillance, conflicts between industrial and artisanal fisheries, and a decline in employment opportunities. Nations like Kenya and Somalia are grappling with the loss of social and economic opportunities, food security, and environmental degradation due to IUU activities[5]. The social fabric of coastal communities is torn as livelihoods are threatened, and the consequences are dire, with reports indicating a 70% decrease in income for affected communities[6].

4. Environmental Effects

IUU fishing exerts immense pressure on marine ecosystems, driven by poor governance, excessive fishing capacity, and destructive practices. Discarding practices contribute to the estimated 7 million tons of fish rejected dead at sea[7], causing environmental harm and biodiversity loss. The implications of IUU activities extend to the depletion of marine habitats, vulnerable ecosystems, and food security. Such activities hinder responsible fisheries management, impeding efforts by nations and international organizations.

5. Piracy in the Horn of Africa: A Consequence of IUU Fishing

The nexus between piracy in the Horn of Africa and IUU fishing reveals a direct correlation. Somali pirates, initially local fishermen, turned to hijacking in response to intimidation from illegal fishing operations. With inadequate law enforcement in Somalia's waters, approximately 700 foreign fishing vessels engage in

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[4] D.A., J.P., & G.P. (2009). Estimating the Worldwide Extent of Illegal Fishing. doi:10.1371/journal.pone.0004570

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[7] FAO, R. (. & F. (2010). Agreement on port state measures to prevent, deter and eliminate illegal, unreported and unregulated fishing. Retrieved July 7, 2015.

unlicensed fishing, further exacerbating the challenges faced by developing countries in controlling such activities[8]. The Western Indian Ocean becomes a hotbed for maritime security issues due to the confluence of illegal fishing and piracy.

6. International Response and Drivers of IUU Fishing

6.1 International Response to Piracy

Initiatives like the European Union's Operation Atalanta aim to combat piracy in the Horn of Africa. However, challenges persist, with allegations of illegal fishing involving EU fishing boats operating in the Indian Ocean. The lack of coordination and conflicting objectives among nations underscore the difficulties in addressing both piracy and IUU fishing effectively[9].

6.2 Drivers of IUU Fishing Activities

Internally, IUU fishing is driven by demographic factors, economic forces, and weak governance. Lack of alternative livelihoods, inadequate governance, and conflicting objectives contribute to the persistence of IUU activities. External drivers, such as the open registry system[10], provide flexibility to fishers to evade legislative constraints. The use of Flags of Convenience and open registers enables vessels to reduce compliance and contract costs, creating economic advantages for IUU operators.

6.3 Organized Crime in the Fishing Industry

IUU fishing serves as a safe haven for organized crime in the fishing industry, involving activities like tax fraud, corruption, human trafficking, money laundering, and drug trafficking. The lack of effective governance, combined with the globalization of capital, facilitates the expansion of transnational criminal networks. Flags of Convenience and open registers provide a cover for these activities,

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[8] J. H. (2011, February 10). The Piracy-Illegal Fishing Nexus in the Western Indian Ocean. Retrieved July 1, 2015, from http://www.academia.edu/6737362/ The_PiracyIllegal_ Fishing_Nexus_in_the_Western_Indian_Ocean Indian Ocean Research Programme

[9] Information sought from Maritime Headquarters of Pakistan where database regarding Operation Atalanta is maintained due participation of PN ships and observers in the mission.

[10] Open Registration is a type of registration under a national flag available to all ships irrespective of nationality.

leading to severe consequences for crew conditions, safety, and environmental norms.

6.4 Addressing the IUU Fishing Menace: A Global Imperative

As IUU fishing continues to thrive, it poses a substantial challenge to fisheries policy makers and undermines the credibility of fisheries management. The interconnected nature of IUU activities demands a comprehensive, global response. International instruments and guidelines have been established, yet implementation remains a key issue. Focused attention on addressing gaps in existing mechanisms is crucial to effectively combat IUU fishing.

7. Conclusion

The menace of IUU fishing is not merely an isolated issue but a global challenge with far-reaching consequences. The economic, social, and environmental impacts underscore the urgency for collaborative efforts to curb IUU activities. The rise of piracy in the Horn of Africa further emphasizes the interconnectedness of maritime security issues with illegal fishing. A concerted, global response is imperative, encompassing improved governance, strengthened enforcement mechanisms, and heightened international cooperation to secure the sustainability of marine ecosystems and livelihoods dependent on fisheries. Only through collective action can the world hope to mitigate the pervasive effects of IUU fishing and secure the future of our oceans.