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The Strait of Malacca: A Crossroad of Climate Change and Vulnerabilities

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Abstract:
The Strait of Malacca, an indispensable artery facilitating global trade, confronts an existential peril exacerbated by climate change. This research comprehensively analyses the intricate interplay between ecological and socioeconomic factors, with a primary focus on India's vulnerabilities and adaptive strategies. The study scrutinizes the escalating sea levels, intensification of storms, and coastal erosion, elucidating their multifaceted impacts on ecosystems, communities, and economies.
The Malacca Straits are one of the world's most vulnerable areas because of their high potential for political conflict and ecological disaster. The areas bordering the Straits are of high bio-diversity and ecologically fragile.
The imperative to foster resilience is underscored, necessitating the exploration of adaptive strategies to empower communities, preserve ecosystems, and foster sustainable development amidst climatic challenges. This research transcends conventional threat assessments, offering a holistic roadmap for India and stakeholders to navigate the complexities of climate change and ensure the enduring prosperity of the Strait of Malacca. It also delves specifically into the vulnerabilities faced by countries bordering the Strait, with a particular focus on India's dependence on the waterway for trade, food security, and energy needs. The need of the hour is to analyse these vulnerabilities, and to pave the way for the development of robust adaptation strategies that ensure the long-term sustainability and resilience of the Strait of Malacca in the face of a changing climate.

Keywords: Strait of Malacca, Climate crisis, Vulnerabilities, Resilience, stakeholders, Adaptive Strategies

Introduction

One critical bottleneck for global trade, particularly concerning significant energy resources, occurs at specific passages connecting production areas to their eventual destinations. The Straits of Malacca is one such crucial chokepoint. The Strait of Malacca has historically served as a crucial hub for international trade, linking the Indian Ocean and the South China Sea over its 600-mile stretch. This strategic waterway has been vital for both Malaysia and the Kingdom of Oman. It facilitates significant maritime traffic, enabling Middle Eastern and European businesses to access Asian markets while fostering the exchange of goods, knowledge, and culture between East and West.
Moreover, the historical significance of the Strait of Malacca extends beyond trade. It once united various Malay kingdoms and port-city states, including Sumatra, Riau-Lingga, and Thai-Malay vassal states, creating a cohesive political and cultural zone. This geostrategic and economic importance of the strait led

to the development of numerous Malay kingdoms and port cities such as Pasai, Aceh, Indragiri, Singapore, Kedah, and Johor, shaping the region's history and prosperity.

During the seventh to eleventh centuries, the Srivijaya empire held dominion over the region, succeeded by the port kingdom of Malacca in the fifteenth century. Recognizing its strategic significance, Western maritime powers, notably the Portuguese in 1511 and the Dutch East India Company from the seventeenth to eighteenth centuries, vied for control over the Straits.The British, acknowledging the necessity of overseeing the Straits for the safety of their merchant vessels en route to China, established a colony in Singapore in 1819. Subsequently, a treaty in

1824 between the British and the Dutch aimed to ensure the accessibility of the Straits to all friendly nations under British protection. In contemporary times, the Malacca Straits have emerged as a pivotal trade route. In 1993 and 1995, the volume of vessels transiting the Straits exceeded 100,000 annually, facilitating the transportation of approximately 3.23 million barrels of crude oil daily.

Annually, approximately 50,000 vessels navigate through the Straits, handling between one-fifth and one-quarter of the world's sea trade, with oil being the second most transported commodity after general cargo. The Straits, particularly the Phillips Channel in the Singapore Strait, are renowned as one of the world's most significant traffic bottlenecks due to their narrow width of about 1.5 nautical miles (2.8 km). Notably, half of all oil shipments transported by sea pass through the Straits. In 2003 alone, 19,154 tankers travelled eastbound through the Straits, carrying over 10 million barrels of oil per day, a trade expected to grow with increasing oil consumption, particularly in China. Currently, oil flows through the Straits exceed those through the Suez and Panama Canals by threefold and fifteen fold, respectively.

However, the escalating frequency of shipping accidents in recent years has been attributed to the high traffic density in the Straits, compounded by its shallow, narrow channels, and shoals. Despite these hazards, the imperatives of economic efficiency compel continued maritime utilization of the Straits.

Moreover, the Malacca Straits boast rich reservoirs of both renewable and non-renewable resources, encompassing productive coastal ecosystems, extensive fisheries, aquaculture, coastal tourism assets, mineral deposits, and valuable natural gas reserves.

The Straits of Malacca are highly susceptible to both political tensions and environmental crises due to their ecological delicacy and significant biodiversity. The regions surrounding the straits are recognized as a biodiversity hotspot known as the "Sunda hotspot." This biodiversity is under threat from deforestation in Sumatra and Peninsular Malaysia, as well as the depletion of coastal mangrove forests and the risk of oil spills. The ecological, social, political, and economic dynamics in the straits are intricately connected and cannot be disentangled.

Map 1, The Strait of Malacca

Strait of Malacca's share of Global exports

There exist five primary global ports, which are Singapore, Port Klang (Kuala Lumpur), Johore, Penang, and Belawan (Medan). Additionally, numerous smaller ports and ferry terminals of regional importance also operate. While Singapore and, to a lesser degree, the other major ports serve as crucial centres for global maritime activities, the minor ports primarily facilitate local trade and the movement of labour.

Around 50,000 vessels traverse the Straits annually, transporting between one-fifth and one-quarter of global maritime trade. Besides general cargo, oil ranks as the most crucial commodity transported. Due to their narrowness, approximately 1.5 nautical miles (2.8 km) at the Phillips Channel in the Singapore Strait, the Straits are a significant bottleneck for maritime traffic worldwide.

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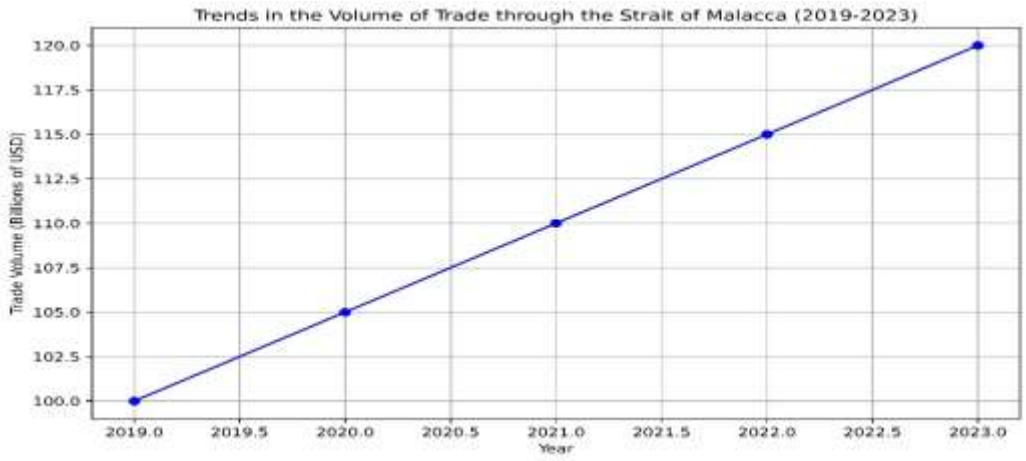

Graph 1

The trade through the Strait of Malacca is vital, especially for China's role in the automotive supply chain, notably in electric vehicles. The U.S. auto industry's contribution to economic growth has dwindled from 4.9 percent of GDP in 1973 to about 3.3 percent in 1990, yet it remains significant, making up nearly 7 percent in 2020, as per a 2022 Deloitte report. Disruptions in China, heavily dependent on the strait for trade, could disrupt crucial component production, impacting vehicle assembly and sales in the West.

Industries like electronics, technology, retail, and fashion heavily rely on components or sourcing from East Asia, which could face shortages in the event of prolonged strait disruptions. Although Western energy needs are less tied to the strait compared to East Asia, global oil price fluctuations and delays in essential medication production due to API sourcing from Asia are potential concerns.

The agriculture and food sectors may also experience availability issues for specialty items sourced from Asia, highlighting the importance of maintaining open trade routes like the Strait of Malacca for global trade stability. These challenges prompt industries to reconsider and diversify supply chains, leveraging technological advancements for better disruption anticipation and response.

Understanding the trade dynamics through the Strait of Malacca is crucial for Western businesses and policymakers, emphasizing the need for innovation, collaboration, and strategic planning to navigate global trade complexities effectively.

Climate Variability and its Impacts on the Strait of Malacca

The Malacca Strait, a crucial conduit for international shipping, fishing grounds, maritime heritage sites, and economic interests, bridging the Indian and Pacific Oceans, according to recent evidences, indicates that the region has been affected by the consequences of global climate change, manifesting in rising sea surface temperatures and levels. Various reports highlight a discernible upward trend in sea levels within the Malacca Strait, with the current rate of increase estimated at 0.46 cm/year.

Primary drivers of this phenomenon include ocean circulation patterns and climatic factors such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation. Studies have established correlations between interannual sea level variability and phenomena like ENSO and the Indian Ocean Dipole (IOD), with sea level rises often associated with La Niña events and negative IOD indices. Additionally, the influence of the Indian Ocean and the South China Sea on sea level anomalies in the Malacca and Singapore Straits has been noted.

While previous research has predominantly focused on the relationship between sea level variability and IOD/ENSO, there is a need to explore the impact of other climatic and oceanographic factors, such as the Madden Julian Oscillation (MJO), on sea level variations in the equatorial Malacca Strait. Furthermore, a comprehensive review of sea level trends in the region is essential for assessing potential future impacts on coastal areas.

Coastal regions surrounding the Malacca Strait are already experiencing adverse effects, including erosion, inundation, and heightened vulnerability to coastal hazards and disasters. Studies have documented significant shoreline retreat and seawater inundation, particularly on the west coast of Peninsular Malaysia and the eastern coast of Sumatra. The long-term consequences of rising sea levels extend beyond coastal damage, potentially altering tidal characteristics and amplifying estuarine tidal ranges.

In particular, estuarine systems like the Kampar estuary on the eastern coast of Sumatra may undergo significant changes in tidal regimes due to sea level variations. Understanding the seasonal correlations between climatic and oceanographic factors and sea level fluctuations in the equatorial Malacca Strait is crucial for assessing future impacts. Additionally, investigating the influence of sea level change on tidal regimes in estuarine areas like the Kampar estuary will provide valuable sights into the broader implications of rising sea levels on coastal ecosystems and communities.

The southern part of the Malacca Strait features relatively shallow bathymetry, approximately 37 meters deep, gradually deepening towards the northwest where it merges with the Andaman Sea, reaching depths of about 200 meters. In the northernmost area, the bottom morphology profile steepens towards the western boundary, reaching depths of 300 meters near Aceh Province, before sloping gradually towards the western coast of Malaysia, with depths ranging from 0 to 100 meters. Conversely, the middle section of the strait exhibits irregular bathymetry, with depths less than 10 meters on the western side and depths ranging from 10 to 40 meters on the eastern land boundary. The southern gate presents further erratic bottom morphology, with depths ranging from 5 to 40 meters. Additionally, the presence of numerous isles, fringing reefs, and sand ridges within the strait hampers water mass flow from the southern entrance, with sand ridge formation attributed to material accumulation from large estuaries along Sumatra's eastern coast.

Geologically, the Malacca Strait is situated within the Sunda Shelf, an extensive low-relief land surface dating back approximately 2.6 million years, which has experienced minimal crustal movements over the past 7 million years. Its current configuration is primarily a result of postglacial sea level rise induced by the melting of land ice in higher latitude regions. Coastal swamp formations characterize both primary lands, with low-slope swamp forests predominantly found on Sumatra's eastern coast, where sediment accumulation is high due to the presence of large estuaries.

The Straits face an annual shipping hazard caused by the persistent haze resulting from wildfires in Sumatra. This haze significantly reduces visibility, sometimes to as low as 200 meters, posing navigation risks in the narrow and bustling trade route.

Concerns about ecological risks due to intensive shipping and industrial growth are discussed by Cleary and Goh (2000) and other researchers. The rising shipping activities and rapid coastal development threaten the environmentally delicate, highly biodiverse surroundings of the Straits.

To enhance navigational safety in the narrow and shallow Straits, the Malaysian Government invested EUR 11 million to install 256 navigational aids and EUR 22 million for a vessel traffic management system. Between 1978 and 1994, there were 476 accidents, including oil spills, in the Straits, averaging 30 accidents annually [1]. Approximately 36% of vessels passing through the Straits are oil tankers, contributing to sea discharges like oil, ballast water, sewage, and solid waste.

By 2000, vessels in the Straits generated an estimated 888,000 tonnes of waste, including 150,000 tonnes of oily bilge water, 18 tonnes of solid waste, and 720,000 tonnes of sewage [2]. While the international community benefits from the waterway, littoral states shoulder the financial burden of ensuring navigational safety and bear the consequences of oil spills and shipping-related pollution.

Additionally, pollutants from various sources such as industries, agriculture, land-use activities, and domestic waste are discharged into the Straits from the shore. Coastal activities like sand mining, mangrove swamp development, and land reclamation further degrade marine life habitats along the coast (source: http://www.fsas.upm.edu.my/~masdec/web/straits.html).

What implications does this have for India?

The rising sea levels attributed to climate change pose a substantial threat to India's coastal regions adjacent to the Strait of Malacca. According to the World Bank, global sea levels have risen by an average of 3.2 millimetres per year since 1993, with accelerated rates observed in recent years. This phenomenon heightens the vulnerability of coastal communities in India, particularly those along the Bay of Bengal and the Arabian Sea. Data from the Ministry of Earth Sciences indicates that sea levels along the Indian coastline have risen by approximately 8.5 inches (21.6 centimetres) over the past century, exacerbating coastal erosion, inundation, and storm surges.

1. (source: www.american.edu/TED/malacca.htm).
2. (Source: http://www.american.edu/TED/malacca.html).

India's maritime trade and navigation activities heavily rely on the smooth functioning of the Strait of Malacca. According to the Indian Ports Association, maritime trade accounts for over 90% of India's international trade volume. Any disruptions in the strait, driven by climate change-induced extreme weather events, can have profound implications for India's economy. Data from the Ministry of Shipping reveals that major Indian ports handle millions of metric tons of cargo annually, with significant portions

transiting through the Strait of Malacca. Disruptions to maritime trade routes can lead to delays, increased costs, and supply chain interruptions, impacting various sectors of the Indian economy.

India's rich marine biodiversity and vibrant fisheries sector face escalating threats from climate change in the Strait of Malacca. The Indian Ocean region is home to diverse ecosystems, including coral reefs, mangroves, and estuaries, which support abundant marine life. However, rising sea temperatures and ocean acidification are altering these ecosystems, jeopardizing fish stocks and livelihoods. According to the Central Marine Fisheries Research Institute, India ranks among the top fish-producing countries globally, with marine fisheries contributing significantly to food security and livelihoods. Nevertheless, climate change-induced disruptions in the Strait of Malacca jeopardize the sustainability of marine resources, posing challenges for India's fisheries sector.

The strategic significance of the Strait of Malacca for India's energy security underscores the geopolitical implications of climate change adversities in the region. India is heavily reliant on oil imports, with significant volumes transported through the strait from the Middle East. Disruptions to maritime trade routes in the strait, driven by extreme weather events or sea level rise, could impact India's energy security and economic stability. Moreover, heightened competition for maritime resources and strategic interests in the region may exacerbate geopolitical tensions, necessitating diplomatic efforts and cooperation among regional stakeholders.

Nurturing Climate Resilience and Sustainable Development in the Strait of Malacca: The Imperative of Strengthening Regional Cooperation

To enhance climate resilience, promote sustainable development, and strengthen regional cooperation, the imperative of fostering collaboration among India, stakeholders in the region, and international partners to address the multifaceted impacts of climate change in the Strait of Malacca, the following measures are necessary.

India and stakeholders in the region must prioritize investments in climate-resilient infrastructure, coastal protection measures, and early warning systems for extreme weather events. This entails upgrading critical infrastructure such as ports, harbours, and coastal defences to withstand rising sea levels, storm surges, and other climate-related hazards. Additionally, the development of comprehensive adaptation strategies is essential to address the specific vulnerabilities of coastal communities and ensure the resilience of critical infrastructure. Collaborative efforts among governments, local communities, academia, and civil society organizations are indispensable for effectively implementing and monitoring these adaptation measures.

Sustainable development practices are fundamental for mitigating the impacts of climate change in the Strait of Malacca and fostering long-term resilience. Investments in renewable energy, such as solar, wind, and tidal power, can reduce reliance on fossil fuels and mitigate greenhouse gas emissions. Furthermore, ecosystem restoration initiatives, including mangrove reforestation and coral reef conservation, can enhance natural resilience and protect coastal communities from climate-related hazards. Sustainable fisheries management is also crucial for preserving marine biodiversity and ensuring the livelihoods of fishing communities. India, as a regional leader, can set an example by implementing policies that prioritize sustainability and environmental conservation in maritime activities and coastal development projects, thereby inspiring other stakeholders to follow suit.

Regional cooperation among littoral states, international organizations, and stakeholders is paramount for effectively addressing the challenges posed by climate change in the Strait of Malacca. Platforms such as

the Indian Ocean Rim Association (IORA) and the Association of Southeast Asian Nations (ASEAN) provide valuable opportunities for dialogue, knowledge exchange, and collaborative action on climate resilience, disaster management, and sustainable development initiatives. By fostering partnerships and sharing best practices, countries in the region can leverage collective expertise and resources to implement innovative solutions and build resilience to climate change impacts.

The imperative of enhancing climate resilience, promoting sustainable development, and strengthening regional cooperation in the Strait of Malacca underscores the urgent need for collaborative action. India, as a key stakeholder in the region, has a pivotal role to play in leading by example and mobilizing collective efforts to address the multifaceted impacts of climate change. By prioritizing investments in climate-resilient infrastructure, embracing sustainable development practices, and fostering partnerships among regional actors, India and stakeholders can navigate the complexities of climate change in the Strait of Malacca and ensure the enduring prosperity of the region for generations to come.

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