The Cascading Effects of Choke Point Disruption on Maritime Trade: A Case Study on the Drying of the Panama Canal.

A dissertation submitted to the

School of Maritime Management, Indian Maritime University, Chennai

in partial fulfilment of the requirement for the award of degree of

Master of Business Administration

in

International Transportation and Logistics Management

by

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INDIAN MARITIME UNIVERSITY

(A Central University, Government of India)

CHENNAI CAMPUS

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SCHOOL OF MARITIME MANAGEMENT

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CHENNAI CAMPUS

CERTIFICATE

This is to certify that this dissertation entitled " **The Cascading Effects of Choke Point Disruption on Maritime Trade: A Case Study on the Drying of the Panama Canal**." Submitted to the School of Maritime Management, Indian Maritime University, Chennai Campus in partial fulfilment of the requirement for awarding the degree, Master of Business Administration in International Transportation and Logistics Management, Indian Maritime University, Chennai is a work of Raghav Kumar Jha (Reg. No: 2203305030).

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DECLARATION

I, **Raghav Kumar Jha (Reg. No: 2203305030),** student of MBA International Transportation and Logistics Management at the School of Maritime Management, Indian Maritime University, Chennai Campus, do hereby declare that the dissertation entitled "**The Cascading Effects of Choke Point Disruption on Maritime Trade: A Case Study on the Drying of the Panama Canal**." is my original work. This report is being submitted in partial fulfilment of the requirement for the award of the degree of Master of Business Administration (MBA) in International Transportation and Logistics Management (ITLM). The dissertation is the output of my learning and observations of my research under the supervision and guidance of **Dr Emil Mathew**, Assistant Professor, School of Maritime Management, Indian Maritime University, Chennai Campus.

I further declare that the information submitted is true and original, to the best of my knowledge.

Raghav Kumar Jha

Place: Chennai

Date: 9/05/2023

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Raghav Kumar Jha

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CHAPTER - I

The Cascading Effects of Choke Point Disruption on Maritime Trade: A Case Study on the Drying of the Panama Canal.

INTRODUCTION:

1.1 INTERNATIONAL MARITIME ORGANIZATION

IMO (International Maritime Organization) is a specialized agency of the United Nations responsible for promoting safe, secure, and efficient shipping on a global scale. Established in 1948, IMO plays a crucial role in setting international standards and regulations for maritime operations and the protection of the marine environment. It serves as a platform for member states and industry stakeholders to collaborate and address challenges faced by the shipping industry. IMO's core objectives include enhancing maritime safety, minimizing pollution from ships, and facilitating international trade by ensuring the smooth flow of goods across the seas. Through its conventions, codes, and guidelines, IMO strives to create a level playing field for ship operators and promote sustainable development in the maritime sector. By fostering cooperation and harmonization among nations, IMO continues to make significant contributions to the safety, security, and sustainability of global shipping.

1.2 MARITIME TRADE AND IMPORTANCE

Maritime trade, often referred to as seaborne trade, is the exchange of goods, commodities, and services via ships across oceans, seas, and other navigable waters. It has been a fundamental aspect of global commerce for centuries, playing a crucial role in shaping economies, cultures, and societies worldwide.

At its core, maritime trade involves the transportation of goods by sea between ports located in different countries or regions. This trade encompasses a wide range of products, including raw materials like oil, minerals, and agricultural produce, as well as manufactured goods, consumer products, and even services such as shipping and logistics.

Historically, maritime trade has been instrumental in facilitating cultural exchange and the spread of ideas, religions, and technologies across distant lands. Ancient civilizations such

as the Phoenicians, Greeks, and Romans established extensive maritime networks that connected disparate regions of the world, enabling the exchange of goods ranging from spices and silk to precious metals and exotic animals.

The development of maritime trade was further accelerated during the Age of Exploration, as European powers sought new trade routes to access valuable resources in Asia, Africa, and the Americas. This era witnessed the rise of powerful trading empires such as Portugal,

Spain, the Netherlands, and England, which established lucrative colonial ventures and trade networks spanning the globe.

The advent of steam power in the 19th century revolutionized maritime trade, leading to the construction of faster and more efficient steamships that could navigate longer distances in shorter time frames. This technological leap significantly reduced the cost and time associated with sea transportation, further expanding the scope and scale of global trade.

In the modern era, maritime trade remains indispensable to the functioning of the global economy. It accounts for the vast majority of international trade by volume, with ships carrying over 90% of the world's goods. Major maritime routes, such as the Panama Canal, Suez Canal, and strategic straits like the Strait of Hormuz and the Strait of Malacca, serve as critical conduits for trade between continents.

Containerization, introduced in the mid-20th century, revolutionized the logistics of maritime trade by standardizing the transportation of goods in uniform containers that can be easily transferred between ships, trucks, and trains. This innovation greatly improved efficiency, speed, and cost-effectiveness in the shipping industry, enabling the globalization of trade on an unprecedented scale.

The economic significance of maritime trade cannot be overstated. It supports millions of jobs worldwide, ranging from shipbuilders and sailors to port workers and logistics professionals. Ports and maritime infrastructure serve as vital nodes in the global supply chain, facilitating the movement of goods and fostering economic development in coastal regions.

However, maritime trade also poses significant environmental and security challenges. Shipping emissions contribute to air and water pollution, while maritime accidents, piracy, and maritime disputes can disrupt trade flows and pose risks to maritime security.

In conclusion, maritime trade is a cornerstone of the global economy, connecting nations, driving economic growth, and shaping the course of history. Despite its challenges, the continued evolution of maritime trade promises to play a pivotal role in the future prosperity and interconnectedness of nations around the world.

1.3 MARITIME TRANSPORT

Marine transport, also known as shipping or maritime transportation, plays a pivotal role in global trade and connectivity. It involves the movement of goods, passengers, and cargo by water, utilizing various types of vessels such as container ships, bulk carriers, tankers, and ferries. With its vast network of shipping routes, ports, and terminals, marine transport provides an efficient and reliable means of transporting goods across long distances. It enables the globalization of industries by connecting countries and continents, fostering international trade, and contributing to economic growth. Furthermore, marine transport offers environmental benefits as ships have lower carbon emissions compared to other modes of transportation, making it a relatively eco-friendly choice. However, the industry also faces challenges such as weather-related disruptions, piracy threats, and the need for robust infrastructure and regulatory frameworks. Despite these challenges, marine transport remains an indispensable component of the global logistics system, serving as a lifeline for international commerce and facilitating the movement of goods and people worldwide. Maritime transport is the backbone of international trade and the global economy. Sea carries over 80% of the volume of international trade in goods, and the percentage is even higher for most developing countries. The IMO facilitates the agreement, adoption, and implementation of rules and standards for shipping on a global scale, enabling the industry to function efficiently worldwide.

1.4 MARITIME PASSAGE AND ITS IMPORTANCE

Maritime chokepoints are strategic bottlenecks in global trade. These are narrow waterways, like straits or canals, that concentrate a massive volume of ship traffic because of their optimal location for connecting major markets. Examples include the Panama Canal, the Suez Canal, and the Strait of Malacca. While chokepoints facilitate efficient trade, their very nature creates vulnerabilities. The primary concern is disruption. Accidents, groundings, or even deliberate actions can cause blockages, leading to delays and rippling effects

throughout global supply chains. The 2021 grounding of the Ever Given in the Suez Canal is a prime example, halting billions of dollars' worth of trade for days. Geopolitical tensions around chokepoints can also pose a threat. Countries controlling these waterways can potentially restrict or tax passage, impacting trade flows. Piracy is another concern, particularly in areas with weak governance. These disruptions can significantly increase shipping costs and insurance premiums.

Despite the risks, chokepoints remain vital arteries of global trade. No viable alternatives currently exist for many chokepoints, and developing new canals or routes is a complex and expensive undertaking. Therefore, ensuring the smooth operation of these chokepoints requires international cooperation on maintaining navigational safety, mitigating geopolitical tensions, and combating piracy.

1.5 THE FRAGILE LIFELINE: EFFECTS OF A DISRUPTING PANAMA CANAL

The tapestry of human civilization is woven with threads of commerce. From the earliest caravans traversing dusty trade routes to the vast maritime networks of today, the exchange of goods has fuelled economic prosperity, cultural exchange, and technological advancements. At the heart of this intricate system lies maritime transportation, the lifeblood of global trade. Arteries of commerce crisscross the world's oceans, carrying a staggering volume of cargo–the raw materials that feed industries, the finished products that grace store shelves, and the vital resources that keep economies humming. However, these vital lifelines converge at strategic points of passage, aptly named choke points, where a significant portion of global trade becomes concentrated.

The rhythmic pulse of global trade is intricately linked to the arteries of maritime transportation. Among these vital conduits, choke points–narrow, strategically positioned waterways–hold immense power. The Panama Canal, a marvel of human ingenuity, exemplifies this critical role. Since its inauguration in 1914, it has revolutionized global commerce, acting as a linchpin for efficient passage between the Atlantic and Pacific Ocean. However, this very dependence introduces a chilling vulnerability. What if this lifeblood of maritime trade were to falter?

This paper delves into the hypothetical scenario of the Panama Canal drying up, a prospect with potentially dire ramifications. We embark on a journey to explore the cascading effects of such a disruption on the intricate tapestry of global trade. By employing a multifaceted approach, we aim to illuminate the far-reaching consequences that would ripple across diverse sectors and geographical regions.

Our exploration begins with scenario modelling, a powerful tool for envisioning the potential impact on global trade routes, shipping costs, and commodity prices. By meticulously crafting a hypothetical situation, we can assess the rerouting of maritime traffic, the strain on alternative routes, and the resulting economic ripple effects.

Furthermore, we delve into the lessons learned from historical disruptions at other maritime chokepoints. By analysing the 2021 Suez Canal blockage, for instance, we can glean valuable insights into the immediate and long-term disruptions to global supply chains. This comparative analysis allows us to identify potential similarities and differences in the cascading effects of a Panama Canal closure, highlighting its unique vulnerabilities.

To gain a deeper understanding of the potential consequences, we enlist the expertise of a diverse range of professionals. Through the Delphi Technique, we harness the collective intelligence of maritime economists, climate scientists, and logistics specialists. By soliciting their informed opinions and fostering iterative discussions, we can arrive at a robust consensus on the most credible and impactful cascading effects.

Finally, we bridge the gap between theory and practice by incorporating qualitative data from industry professionals. Interviews with shipping company representatives and port managers will shed light on the practical challenges they would face in a disrupted scenario. This mixed methods approach, encompassing both quantitative and qualitative data, will provide a comprehensive and nuanced picture of the potential ramifications.

This paper serves as a stark reminder of the interconnectedness of our world. The potential drying up of the Panama Canal serves as a powerful case study, urging us to contemplate the fragility of vital trade arteries and the importance of proactive strategies to mitigate disruptions and ensure the resilience of global maritime trade. In conclusion, this research paper seeks to contribute valuable knowledge to the discourse on global trade resilience by examining the potential consequences of a Panama Canal disruption through a multifaceted lens. By shedding light on the potential ramifications, this research can inform policy decisions and adaptation strategies aimed at mitigating the impact on global trade and

fostering resilience within the maritime transportation system. The potential drying up of the Panama Canal serves as a stark reminder of the delicate balance upon which global trade rests. Understanding the cascading effects of such a disruption is not merely an academic exercise, but a crucial step towards ensuring the continued smooth flow of commerce in a world facing an uncertain future.

1.6 RESEARCH QUESTION

What are the cascading effects (e.g., price fluctuations, supply chain disruptions) of Panama Canal drying and how this disruption is affecting the maritime industry?

1.7 OBJECTIVES

To understand the potential cascading effects of the Panama Canal drying up on various aspects of maritime trade, including:

- Disruptions to global trade flows and supply chains.
- Economic impacts on specific sectors and businesses reliant on the canal.
- Potential logistical challenges and alternative shipping routes.

1.8 PROJECT SCOPE

This research will investigate the cascading effects of a specific choke point disruption - the recent drought affecting the Panama Canal. The study will undertake a comprehensive review of literature across various disciplines. This includes maritime trade, choke points and their impact, and the Panama Canal itself. It will focus on the maritime industry, analyzing how this disruption is affecting shipping companies, ports, and logistics. The research will consider the perspectives of diverse stakeholders, encompassing shipping companies, port authorities and policymakers. This multi-faceted approach will ensure a holistic understanding of the issue. The ongoing drought, primarily in 2023 and 2024, will be the limited timeframe. Ultimately, the study will provide actionable recommendations for policymakers, industry leaders, and researchers. These recommendations will target the enhancement of global trade network resilience and the mitigation of vulnerabilities associated with choke points like the Panama Canal.

1.9 RESEARCH METHODOLOGY

The research methodology for the study of chokepoint disruptions will involve the following steps:

Literature review:

A comprehensive review of relevant literature, including academic articles, reports, and policy documents, will be conducted to identify to study chokepoint disruptions and impacts on maritime trade and the drying of the Panama Canal.

Data analysis:

Data on the economic, environmental, and various cascading effects will be collected and analyzed using appropriate statistical methods. The analysis will aim to identify the present condition of the Panama Canal and its impact on maritime trade.

Expert consultations:

Expert consultations with stakeholders, including port officials, industry, representatives, and experts, will be conducted to gather insights and perspectives on the current state of drought conditions and its impact on maritime trade and stakeholders.

Recommendations:

Based on the findings of the study, we will develop recommendations to make situations better. The recommendations will be aimed at policymakers, port authorities, and other stakeholders involved.

1.10 DATA COLLECTION

Primary Data: 100 responses were collected from circulating the questionnaire containing 31 relevant questions and a detailed analysis of the results obtained is included with graphs, pie charts and interpretations.

1.11 LIMITATIONS OF STUDY

This research will focus solely on the recent drought and its impact, not a complete closure of the canal.

- The scope is limited to the maritime industry, excluding broader economic or environmental consequences.
- Data availability for specific aspects of the disruption and its effects might be limited.

CHAPTER - II

2.1 THE LITERATURE REVIEW

2.2 Topic: Cascading impacts from climatic shocks to food trade chokepoints–an update.

Date: 08 December 2023

Author: Richard King, Ramon Key, Ramiro Parrado, Elisa Delpiazzo, Francesco Bosello, Chris West

A 2022 Chatham House article explored potential disruptions to the global food trade caused by climate change affecting chokepoints like canals. The study modeled the effects of these disruptions in 2030. Interestingly, in late 2023, a drought caused low water levels in the Panama Canal, mirroring one scenario modeled in the earlier research. This new reality highlights the need for updated analysis, and this article reports the findings of a follow-up study using more recent data and a wider range of climate scenarios.

2.3 Topic: Strategic Maritime Chokepoints: Perspectives from the Global Shipping and Port Sectors.

Date: 05 April 2018

Author: Rockford Weitz

This passage reveals a key difference in perspective between global shipping companies and the industries that support them. While shipping companies see chokepoints as unavoidable geographical features, support industries like port operators and repair facilities view them as strategic advantages. Chokepoints concentrate a large volume of ships in a confined area, creating a lucrative market for these supporting businesses. This highlights how the same geographic constraint can hold different significance for different parts of the maritime industry.

2.4 Topic: The Red Sea Crisis: ramifications for vessel operations, shipping networks, and maritime supply chains.

Date: 20 February 2024

Author: Theo Notteboom, Hercules Haralambides, Kevin Cullinane

The Red Sea crisis is a new disruption to global shipping and logistics, following a series of challenges like the Panama Canal drought and the Suez Canal blockage. Houthi rebels targeting ships in the Red Sea escalated tensions and negatively impacted trade. This editorial analyzes the short-term impacts on shipping operations, freight rates, and global supply chains. The full effects remain unclear until the crisis is resolved, as the conditions for safe passage through the Red Sea are uncertain.

2.5 Topic: Disruption of maritime trade chokepoints and the global LNG trade: An agent-based modelling approach.

Date: 21 September 2022

Author: Abel Meza, Ibrahim Ari, Mohammed Al Sada, Muammer Koç

Chokepoints are vital for global energy transport due to limited alternative routes. Blockages, like the 2021 Suez Canal closure, disrupt energy supplies. This study developed an LNG market model to simulate disruptions at key chokepoints (Panama Canal, Suez Canal/Bab el-Mandeb, Malacca Strait). The model shows disruptions significantly impact LNG trade and exports. The findings urge collaboration to secure trade routes, maintain safe corridors, explore alternative passages, and decentralize LNG plants for access to diverse routes. Additionally, importers should integrate gas markets with pipelines, seek domestic resources, and diversify energy sources to lessen reliance on remote suppliers.

2.6 Topic: Assessing impacts to maritime shipping from marine chokepoint closures.

Date: 11 July 2023

Author: Lincoln F. Pratson

The Suez Canal blockage and reduced Bosporus Strait traffic highlight the vulnerability of maritime chokepoints. Researchers used data to estimate trade flow changes if specific chokepoints closed. They found significant impacts on trade through alternate routes and for countries reliant on specific chokepoints. The study identifies critical chokepoints like the Danish Straits, Bosporus Strait, Strait of Hormuz, and South/East China Seas. Additionally, the analysis predicts delays and disruptions in coastal ports long after a blockage is resolved, impacting global supply chains.

2.7 Topic: Maritime choke points and its impacts on global economy if disturbed.

Date: October 2021

Author: Chulantha Gunathilake

This study focuses on the economic impact of disruptions at maritime chokepoints, highlighting the potential for severe consequences to the global economy, especially regarding oil and commodity trade. Since 90% of global trade relies on maritime transport through these chokepoints, their uninterrupted operation is crucial. Maintaining these routes saves costs and ensures timely deliveries, which are vital for a stable global economy. The study promises to explore disruptive threats to chokepoints and potential countermeasures, recognizing the greater impact such disruptions would have on low- and middle-income countries.

CHAPTER - III

OVERVIEW OF PANAMA CANAL AND ITS DISRUPTION

3.1 MARITIME PASSAGE AND SEA ROUTES

Maritime passage refers to the transportation of goods or people by sea. It's a crucial aspect of global trade and transportation, as ships are able to carry large quantities of cargo over long distances efficiently and economically. Maritime passages can vary in terms of distance, duration, and the specific routes taken depending on the origin and destination of the goods or people being transported.

Maritime passages have played a significant role throughout history, enabling the exchange of goods, ideas, and cultures between different regions of the world. Today, major maritime passages include well-established shipping lanes, such as the Panama Canal, the Suez Canal, and various straits and channels connecting major bodies of water.

International straits, which are narrow passages connecting two areas of high seas, offer another form of maritime passage. Here, the concept of transit passage applies. This allows for continuous and expeditious travel through the strait, without stopping or deviating from the route, unless forced by circumstances.

These passages are vital for international trade, facilitating the movement of goods between continents and enabling countries to access resources, markets, and products from around the globe. The efficiency and reliability of maritime passages are critical factors in determining the cost and speed of transportation, which in turn can impact global commerce and economic development.

3.2 CHOKEPOINTS

Chokepoints are narrow maritime passages that serve as critical junctures in global trade and transportation, often connecting larger bodies of water and facilitating the movement of goods, energy resources, and military vessels between regions. These strategic passages, such as the Strait of Hormuz, Strait of Malacca, Suez Canal, and Panama Canal, play a vital role in shaping international commerce and security. Control over chokepoints or disruptions to their operation can have significant economic, political, and military consequences, impacting global shipping routes, energy supply chains, and geopolitical dynamics. Thus, chokepoints are closely

monitored and managed by governments, international organizations, and stakeholders to ensure the security and stability of maritime trade and transportation networks.

3.3 IMPORTANCE OF CHOKEPOINT

Chokepoints play a crucial role in global trade, transportation, and security due to several key reasons:

1. Critical Trade Routes: Chokepoints are often situated along major trade routes, serving as essential passages for the movement of goods and commodities between regions. They facilitate the efficient transportation of goods by sea, allowing countries to access markets, resources, and products from around the world.

2. Energy Security: Many chokepoints are vital for the transportation of energy resources, particularly oil and natural gas. These passages enable the flow of energy supplies from producing regions to consuming markets, ensuring global energy security. Disruptions in these chokepoints can lead to fluctuations in energy prices and supply shortages, impacting economies worldwide.

3. Reduced Transportation Costs and Time: Chokepoints provide shorter and more efficient maritime routes, reducing transportation costs and time for shipping companies. By avoiding longer voyages around continents, ships save fuel, lower operational expenses, and reach their destinations faster, contributing to smooth trade flows and economic growth.

4. Strategic Significance: Control over chokepoints confers strategic advantages to countries and entities that dominate these passages. Governments and military forces can leverage chokepoints to project power, protect national interests, and regulate maritime traffic. The ability to control or influence these critical transit points enhances geopolitical influence and security.

5. International Security Concerns: Chokepoints are vulnerable to various security threats, including piracy, terrorism, and maritime disputes. Ensuring the security and stability of these passages is essential to safeguarding global trade and maintaining peace and stability in maritime regions. International cooperation and security measures are necessary to address these challenges effectively.

6. Environmental Protection: Chokepoints are sensitive environmental areas that require careful management to prevent pollution, habitat degradation, and ecological damage. Implementing measures to mitigate environmental risks in these passages is crucial for preserving marine ecosystems and maintaining sustainable maritime transportation.

Chokepoints are indispensable components of the global maritime infrastructure, serving as vital conduits for trade, energy, and security. Recognizing their importance and addressing the challenges associated with them are essential for fostering international cooperation, economic prosperity, and sustainable development.

3.4 REASONS FOR CHOKEPOINT DISRUPTION

Various factors can disrupt chokepoints, including:

1. Natural Events: Natural disasters such as earthquakes, tsunamis, hurricanes, and severe storms can disrupt maritime passages by causing damage to infrastructure, altering navigation channels, or creating hazardous conditions for shipping.

2. Man-Made Accidents: Accidents such as ship collisions, groundings, or mechanical failures can block or impede maritime passages, leading to temporary closures or restrictions on navigation until the situation is resolved.

3. Security Incidents: Chokepoints are vulnerable to security threats such as piracy, terrorism, and armed conflict. Acts of sabotage, hijacking, or attacks on vessels passing through these passages can disrupt maritime traffic and pose risks to shipping.

4. Geopolitical Tensions: Political tensions, territorial disputes, or international conflicts can lead to disruptions in chokepoints as countries assert control over these strategic passages, implement sanctions, or impose blockades to exert influence or pressure on adversaries.

5. Environmental Concerns: Environmental factors such as oil spills, pollution, or ecological disasters can impact maritime passages, necessitating cleanup efforts, temporary closures, or navigational restrictions to mitigate environmental damage and protect marine ecosystems.

6. Infrastructure Maintenance: Regular maintenance, dredging, or construction work may be required to upkeep maritime infrastructure such as channels, locks, or bridges in chokepoints.

Scheduled maintenance activities can temporarily disrupt navigation or require the closure of passages until work is completed.

7. Technological Challenges: Technological failures or malfunctions, such as problems with navigation systems, communication equipment, or vessel propulsion systems, can lead to disruptions in maritime passages and require assistance or intervention to resolve.

Overall, disruptions in chokepoints can have significant implications for global trade, transportation, and security, highlighting the importance of managing risks, enhancing resilience, and promoting cooperation among stakeholders to address the challenges associated with maritime passages.

3.5 TYPES OF CHOKEPOINT DISRUPTION

Chokepoint disruptions can be categorized into two main types based on their impact and duration:

1. **Temporary Disruptions:** These are short-term events that cause delays or limited closures but don't completely halt traffic flow. Examples include:

- **Navigation Issues:** Poor weather conditions like fog or storms causing visibility problems, or strong currents making navigation difficult.
- **Accidents:** Groundings, collisions, or mechanical failures involving large ships that block passage for a limited time.
- **Minor Security Incidents:** Piracy attempts or isolated security threats that can be addressed quickly.
- **Infrastructure Issues:** Short-term maintenance work or equipment malfunctions in canals or bridges leading to delays.

2. **Major Disruptions:** These are more severe events that significantly hinder or completely halt traffic flow for a longer period. Examples include:

- **Natural Disasters:** Severe storms, typhoons, or earthquakes causing significant damage to infrastructure or creating hazardous conditions that necessitate closure.
- **Major Accidents:** Large-scale accidents involving multiple ships or catastrophic equipment failures blocking the choke point for an extended period.

- **Deliberate Blockades:** Political tensions leading to intentional closure of a choke point by a bordering nation.
- **Large-Scale Security Threats:** Widespread piracy attacks or terrorist activity significantly disrupting traffic flow and requiring a coordinated response.
- **Infrastructure Failure:** Catastrophic breakdowns or collapses within choke point infrastructure like canals or bridges, leading to long-term closures.

The severity of a chokepoint disruption depends on the type of event, its duration, and the specific choke point itself. For instance, a temporary closure due to bad weather might have less impact than a deliberate blockade by a nation controlling a critical strait.

3.6 MAJOR CHOKEPOINTS

Categories of Chokepoints:

- **Straits:** These are narrow passages between two larger bodies of water. Here are some of the most significant:
  - **Strait of Hormuz (Middle East):** Links the Persian Gulf to the Arabian Sea. Carries a significant portion of the world's oil shipments.
  - **Strait of Malacca (Southeast Asia):** Connects the Indian Ocean to the Pacific Ocean. One of the busiest shipping lanes globally.
  - **Suez Canal (Egypt):** An artificial waterway connecting the Red Sea to the Mediterranean Sea. Vital for transporting goods between Asia and Europe.
  - **Strait of Dover (Europe):** Connects the English Channel to the North Sea. Important for trade between the UK and mainland Europe.
  - **Bering Strait (between Russia and Alaska):** Connects the Arctic Ocean to the Pacific Ocean. Strategic location with growing importance due to melting arctic ice.
- **Canals:** These are man-made waterways that allow ships to bypass natural obstacles. Here are some key examples:
  - **Panama Canal (Panama):** Connects the Atlantic and Pacific Ocean. Facilitates trade between North and South America, as well as Asia and the Americas.
  - **Kiel Canal (Germany):** Connects the North Sea to the Baltic Sea. Reduces travel time for ships traveling between these regions.
  - **Suez Canal (mentioned above):** Also falls under the canal category.

- **Geographical Features:** These are underwater features that restrict the passage of large ships. Examples include:
  - **Denmark Strait (between Iceland and Greenland):** Deep underwater ridge that can be challenging for some ships to navigate.
  - **Florida Straits (between Florida and Cuba):** Shallow waters and coral reefs that require careful navigation.

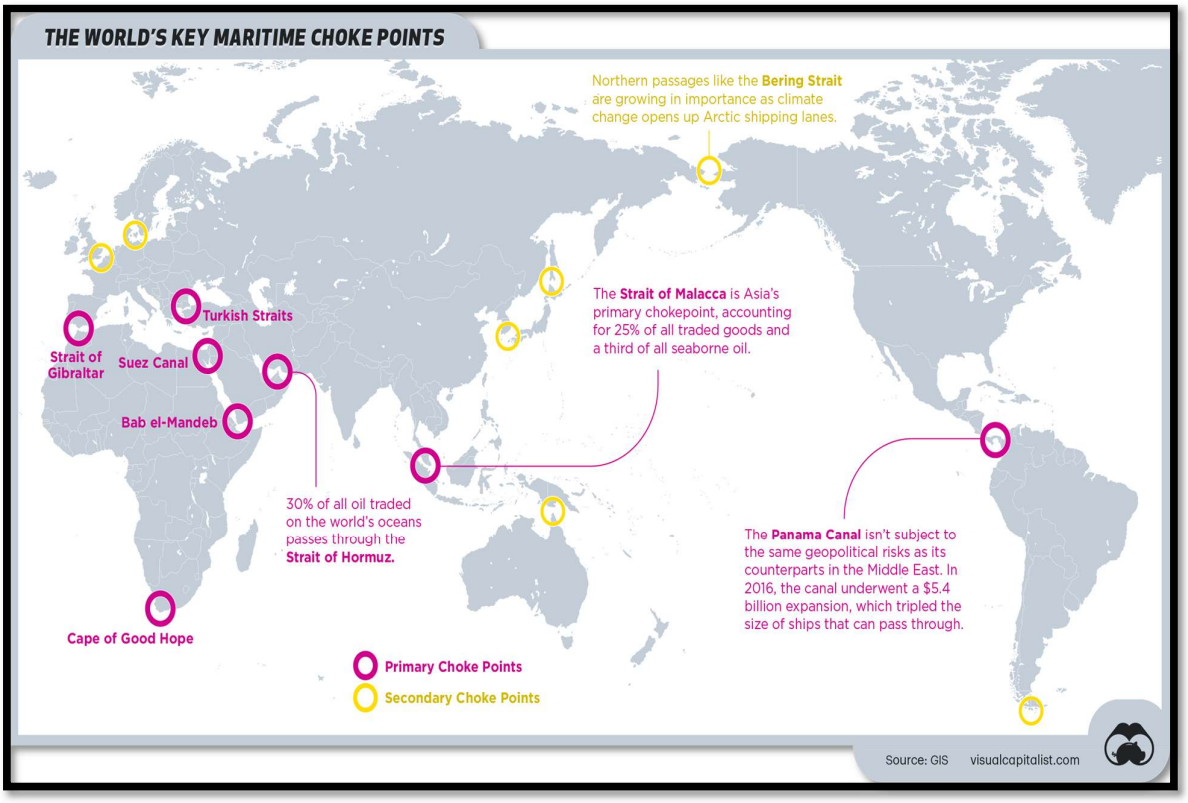

Figure 1 Key maritime choke points **Source: Visualcapitalist.com**

3.7 STRAIT OF HORMUZ

The most significant chokepoint in the globe is the Strait of Hormuz. The Strait of Hormuz, designated as a very important chokepoint with no other option, gives ships direct access to the otherwise inaccessible Persian Gulf. Ships bound for or arriving from China, Japan, India, South Korea, and Singapore are limited to operating inside a two-mile-wide shipping lane, which narrows to only 21 miles at its narrowest point. According to EIA estimates, this chokepoint handles almost 30% of the world's traffic in LNG and other liquids, including crude oil. Several Gulf Cooperation Council nations, such as Saudi Arabia, Kuwait, the United Arab

Emirates, Qatar, Bahrain, and Oman, have been recognised as among of the world's most reliant on food imports. Regarding oil, the only countries with pipeline capacity to go across the Strait of Hormuz are Saudi Arabia and the United Arab Emirates (UAE); other possible rerouting alternatives to get around Hormuz are not operational at present.

Disruptions are nothing new to the Strait. Iranian police boats opened fire on a cargo ship in 2015, then boarded and took control of it. While Iran's threats to block the Strait of Hormuz have long been a source of anxiety for the oil markets, Chatham House notes that climate change may soon cause storms to strike the region.

3.8 THE PANAMA CANAL

The Panama Canal, which has just undergone its first extension since 1914 to allow bigger ships to pass through its locks, serves as a vital link between the markets in the West and Asia. It now handles the majority of US soybean and maize shipments to Asian markets, with a length of 50 miles and a width of just 110 feet. This is predicted to skyrocket in the near future, with China's need contributing about half of the increase in the world's food consumption by 2050. By 2025, it is anticipated that the nation would import more than 100 million tonnes of soybeans annually.

The Canal has had several disruptions over the last ten years, mostly as a result of unusual weather patterns. Periods of floods, drought, and fog have caused the Canal to temporarily close, experience limitations, and experience delays.

There are alternatives to the Canal: if necessary, ships can reroute through the Drake Passage, the Horn of Africa, and the Straits of Magellan; however, this would incur significant additional expenses and add 8,000 miles to the voyage.

3.9 BAB-EL-MANDEB

Bab-el-Mandeb Strait is the entryway to both the Mediterranean and Indian oceans, and it acts as a chokepoint between the Horn of Africa and the Middle East. Tankers must go through a two-mile-wide navigation gap in both directions, with a maximum width of just 18 miles.

Additionally, it is one of the three main chokepoints that provide access across the Mediterranean Sea to Algeria, Tunisia, Libya, and Egypt, nations that import 70% of their wheat. Moreover, this strait is the transit point for 32% of the world's potassium chloride, which is the most traded fertiliser.

If it closed, ships leaving the Persian Gulf would not be able to access the Summed Pipeline or the Suez Canal, making it impossible for oil flows from Europe and North Africa to reach Asian markets by the most direct route.

So far, some of the most common sources of interruption in the region appear to be armed conflict and political instability. Due to Saudi bombings, all major ports in Yemen were closed in 2015. The following year, rebels launched anti-shipping missiles on a UAE ship, and throughout 2017, there were several assaults on ships passing through the strait.

Researchers at Chatham House caution that the Strait of Bab-el-Mandeb is still vulnerable to instability in neighbouring Somalia and spillover from the conflict in Yemen.

3.10 STRAIT OF MALACCA

The Strait of Malacca, Asia's principal chokepoint, enables ships to travel the quickest maritime route between suppliers in the Persian Gulf and Asian markets, including China, Japan, South Korea, and the Pacific Rim. The strait's oil flow is mostly composed of crude oil, with petroleum products accounting for the remaining portion. According to the EIA, the vessel's required passage via a tight 1.7-mile corridor provides "a natural bottleneck with the potential for collisions, grounding, or oil spills. "According to the International Maritime Bureau's Piracy Reporting Centre, the biggest hazards to ships include hijackings, attempted theft, and piracy. Attacks on ships are on the rise.

Rerouting, the EIA has cautioned, is not a viable option since it would monopolise global shipping capacity, increase shipping costs, and perhaps have an impact on energy prices. Additionally, it would interfere with the flow of LNG to the largest importing nations, such as South Korea and Japan, from sources in Africa and the Persian Gulf.

China and Myanmar launched the Myanmar-China natural gas pipeline, which was fully operational in June of this year, providing one way around the current oil supply chain. In

addition, the strait handles 18% of the world's grain trade, for which there is no other viable means of transportation.

3.11 SUEZ CANAL

Situated in Egypt, the Suez Canal is a globally recognised passageway that links the Mediterranean and Red Seas.

It has grown significantly over the last 20 years; between 2000 and 2015, the amount of wheat imported into the region via the Suez Canal increased by 120%. Despite handling mostly food traffic, 17% and 6% of all Suez cargoes were made up of petroleum and LNG, respectively.

Like the Panama Canal, Suez underwent expansion in 2010, allowing the majority of bulk carriers and all container ships in the world to pass through.

Due to a combination of storms and ship attacks during the previous seven years, the canal appears to be in danger, much like the majority of the world's major maritime chokepoints. As a result of heightened terrorist activity and strikes in the Sinai Peninsula, Chatham House is now warning that there may be a greater chance of an attack on the Suez Canal.

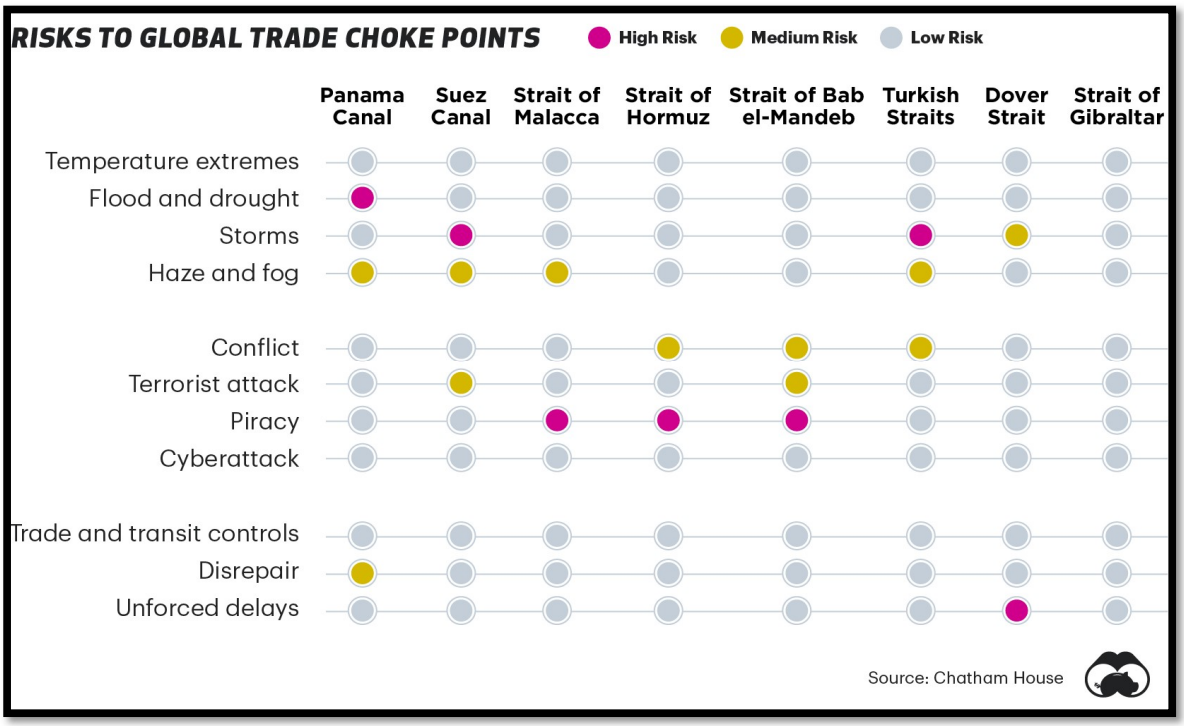

Figure 2 Risks to global choke points **Source: Chatham House**

IMPLICATIONS FROM CHART

Image shows that there are a variety of risks to global trade choke points. These risks can be categorized as natural, man-made, and accidental.

The image ranks the likelihood of these risks occurring at different choke points around the world. The Panama Canal and Suez Canal are ranked as high risk for floods and droughts, while the Strait of Malacca is ranked as medium risk. The Strait of Hormuz and Bab el-Mandeb Strait are ranked as high risk for conflict.

3.12 THE DRYING OF PANAMA CANAL AND ITS EFFECTS.

The Panama Canal, a marvel of engineering, slices through the heart of Central America, serving as a global trade lynchpin. Annually, it sees a staggering volume of traffic, with roughly 13,000 to 14,000 vessels navigating its waters. This translates to a significant financial contribution, generating around $2.6 billion in tolls and fees alone.

The canal's true importance lies in its ability to reshape global trade routes. By connecting the Atlantic and Pacific Ocean, it eliminates the treacherous and time-consuming journey around Cape Horn in South America. This shortcut facilitates trade between continents, impacting over 145 routes. Container ships reign supreme, constituting a large portion of canal traffic, particularly the newer, wider Neo-Panamax vessels. These giants of the sea benefit immensely from the canal's expansion, allowing them to carry even more cargo. Additionally, Liquefied Natural Gas (LNG) carriers are increasingly utilizing the canal, highlighting its adaptability to evolving trade needs.

The Panama Canal's impact extends far beyond its immediate vicinity. It serves as a vital artery for the United States, handling nearly 40% of its container traffic. Any disruption here creates ripples throughout global supply chains, potentially leading to delays, shortages, and price hikes for consumers worldwide. The efficient movement of goods through the canal fosters economic growth for nations on both sides of the Americas and beyond. It's a testament to human ingenuity, facilitating the exchange of goods and propelling international trade to new heights.

3.13 REASONS FOR DRYING OF PANAMA CANAL

The Panama Canal, a vital artery of global trade, is facing an unprecedented challenge: drying up. This isn't science fiction; it's a harsh reality brought on by a confluence of factors. The primary culprit is a prolonged drought gripping Panama since early 2023. Rainfall levels have plummeted, making 2023 one of the driest years on record. This lack of precipitation severely impacts Gatun Lake, the artificial reservoir that provides the water needed to operate the canal's locks.

El Nino, a cyclical weather pattern known for bringing dry conditions to the Pacific region, has exacerbated the situation. The intense 2023 El Nino season extended into 2024, further reducing rainfall and causing water levels in Gatun Lake to fall dramatically. By January 2024, water levels were at record lows, almost 6 feet lower than the previous year. This decline has a domino effect. Lower water levels in Gatun Lake mean there's less water available to raise and lower ships through the canal's locks.

The Panama Canal Authority (ACP) has been forced to take drastic measures. To conserve water, they've restricted the number and size of ships allowed to transit the canal. This has resulted in longer wait times, frustrating delays, and ultimately, a disruption to global supply chains. Imagine container ships carrying everything from electronics to medical supplies stuck in a queue, unable to deliver their cargo on time.

The economic impact is significant, with rising shipping costs and potential shortages of essential goods. Beyond the immediate crisis, the drying of the Panama Canal raises serious concerns about the long-term viability of this crucial waterway. Scientists point to climate change as a major underlying factor. Rising global temperatures contribute to altered weather patterns, making droughts more frequent and severe. The Amazon rainforest, a vital source of moisture for Central America, is also under siege from deforestation. This deforestation disrupts rainfall patterns and weakens the ability of the rainforest to regulate regional climate.

The future of the Panama Canal hangs in the balance. The ACP is exploring various solutions, including water-saving measures within the canal system and potential expansion projects to increase water capacity. However, these solutions are complex and expensive. The international community also has a role to play. Addressing climate change through emissions reduction and sustainable practices is critical. Protecting the Amazon rainforest is another crucial step.

The drying of the Panama Canal is a stark wake-up call. It highlights the vulnerability of global infrastructure to climate change and the interconnectedness of our world. Collaborative efforts are needed to ensure the continued smooth operation of this vital waterway and prevent a potential chokehold on global trade.

3.14 OVERVIEW OF PANAMA CANAL

The Panama Canal, together with its locks, spans approximately 80 km to connect the Pacific and Atlantic seas. In the centre of the canal, at a height of 26 metres above sea level, is an artificial lake known as Gatun Lake. Therefore, in order to lift ships to lake level and reduce them to sea level, three locks are required.

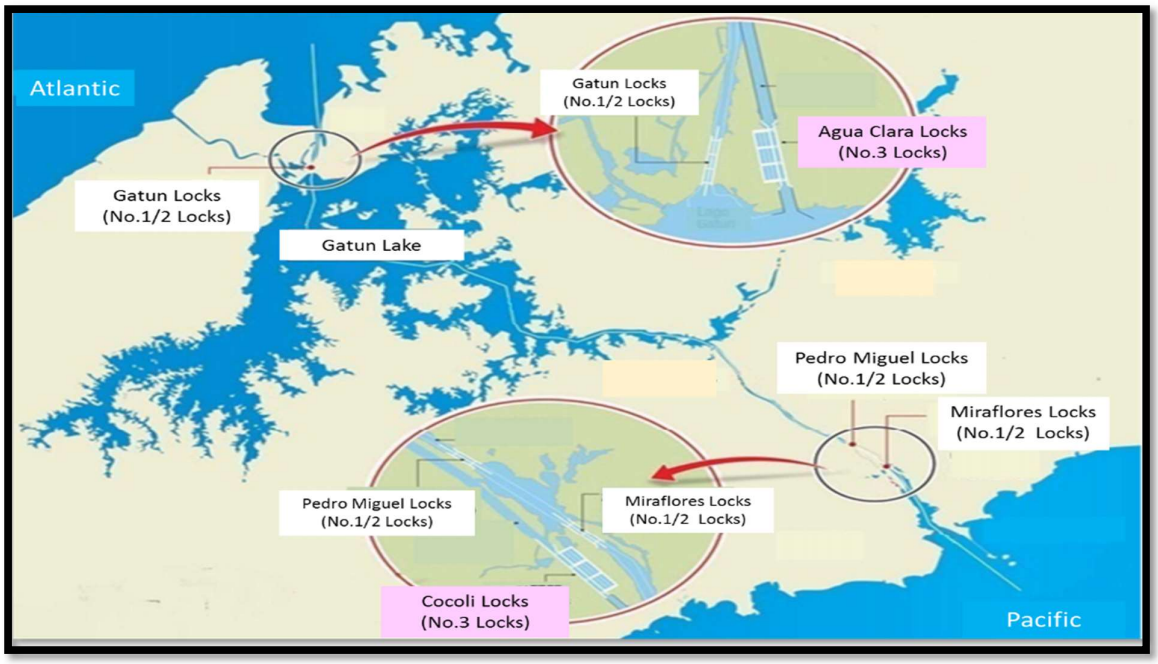

Figure 3 Overview of Panama Canal **Source: Panama Canal Authority**

3.14.1 STRUCTURE OF PANAMA CANAL

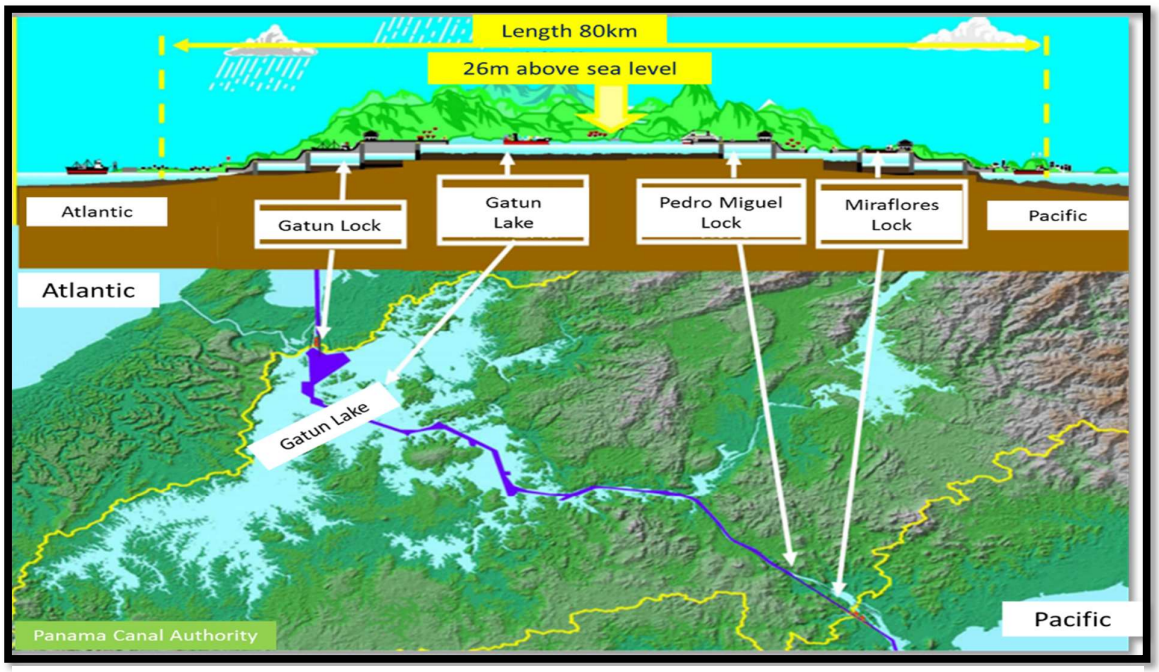

Figure 4 Structure of Panama Canal **Source: Panama Canal Authority**

3.14.2 PATH AND LOCKS OF THE PANAMA CANAL

Ships navigate the Miraflores and Pedro Miguel locks on the Pacific side of the canal, as well as the Gatun Locks on the Atlantic side. The canal was enlarged in response to the growing volume of trade and size of ships. It opened on June 26, 2016, and now consists of the Cocoli Locks on the Pacific side and the Agua Clara Locks on the Atlantic side. The new, extended locks have one lane, whereas the original locks had two lanes. As a result, the new locks are designated number three, while the old locks are numbers one and two.

	No. 1/No. 2 LOCKS		No. 3 LOCKS	
	CHAMBER	SHIP SIZE	CHAMBER	SHIP SIZE
LENGTH	305 m	294 m	427 m	366 m
WIDTH	33.5 m	32.3 m	55 m	49 m
DEPTH	12.6 m	12.0 m	18.3 m	15.2 m

Table *1* Path and Locks of Panama *Canal* **Source: Panama Canal Authority**

3.15 PANAMA CANAL DROUGHT SLOWS CARGO TRAFFIC

This year, at the beginning of the dry season, the lake that makes the Panama Canal possible recorded its lowest water level ever. This implies that a significantly less number of ships will be able to navigate the canal. It is probable that the severe drought, which is being worsened by the continuing El Niño that is impacting the whole region, including Gatun Lake, will persist until May.

In comparison to the previous year, the Panama Canal Authority has cut daily traffic via the constricted corridor by over 40%. Longer ocean routes have already caused several ships to detour, raising expenses and carbon emissions. Additionally, the multinational shipping giant Maersk has declared that they will be moving part of their goods by rail.

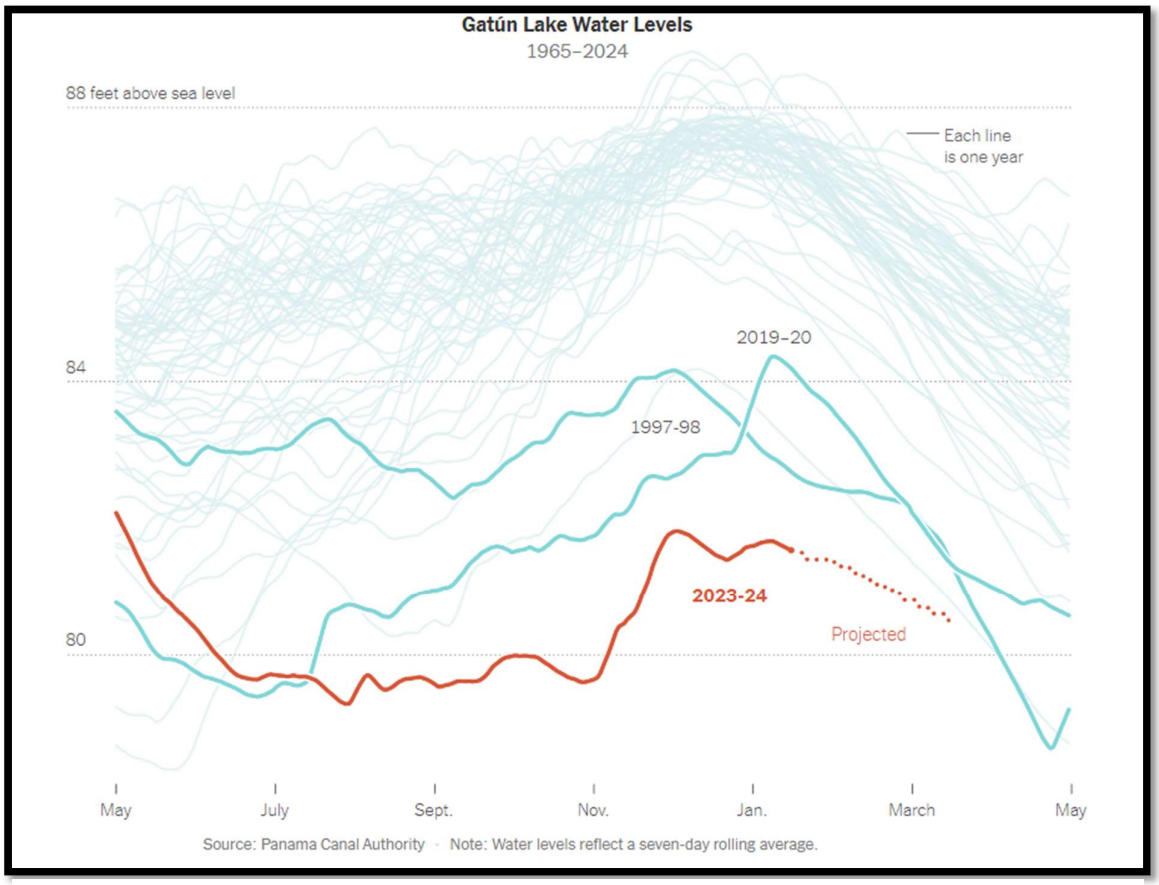

Figure 5 Gatun Lake Water Levels **Source: Panama Canal Authority**

Although the dry season in Panama normally lasts from January to May, rainfall patterns have become considerably less predictable due to climate change. As a result, the operating

limitations of canal infrastructure may be exceeded by more severe droughts and intense floods. Significant amounts of moisture from the reservoir and its watershed are also evaporated by rising temperatures.

Weigh limitations were put in place during earlier droughts because larger vessels ran the danger of hitting aground in the shallower water. An estimated 5% of seaborne trade, including 46% of container traffic between the US East Coast and Northeast Asia, is handled by the canal on a regular basis. However, the Panama Canal Authority started implementing the severe measure of lowering traffic last summer. Since October, toll revenues have decreased by $100 million per month. For each manoeuvre to raise and lower vessels through the locks and out into the sea, about 50 million gallons are used from its reservoirs.

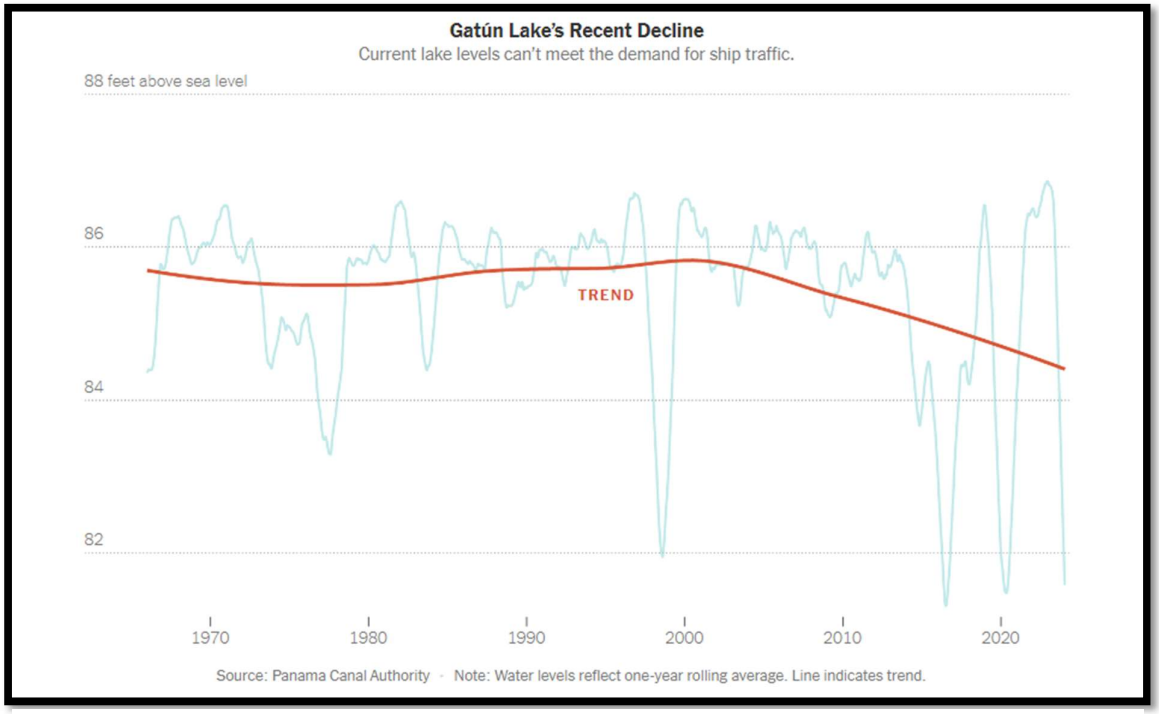

Figure 6 Gatun Lake Water Level Recent Decline **Source: Panama Canal Authority**

But when it comes to lake levels, what enters and what exits the lake are the two factors. Water needs have also increased dramatically. Since the 1950s, the population of Panama has increased fourfold, and the country's reservoirs, Gatun Lake and the smaller Alajuela, provide safe drinking water to over half of the country. It used to make up a relatively small portion of all water usage, but these days it accounts for four or five lockages per day.

Since the canal's first opening in 1914, there has been a steady increase in demand for international commerce. Travellers who would normally have to go around the southernmost point of South America or across the Red Sea, where Houthi hostilities have recently disrupted trade, can save thousands of kilometres by bypassing the small isthmus.

Two additional locks were constructed as part of an upgrade that was finished in 2016 to handle much larger "neo-Panamax" ships, which are heavier, bigger, and need deeper water to pass through the corridor when fully loaded. According to a previous Times investigation, canal authorities disregarded advice that the extension would not be successful unless they had fresh water sources.

"Over the past 100 years, all of the demands on that water have increased, but none of the inputs have." Also, the Panama Canal Authority is looking towards longer-term solutions.

The most notable contender might be a newly constructed reservoir located west of Gatun Lake on the Indio River. However, the Panama Canal Authority is prohibited by law from building reservoirs in watersheds other than the one that supplies its current lakes, so any significant further actions will first have to deal with this legal obstacle.

The Authority has also looked eastward, to Bayano Lake, but accessing it would require pipelining the water thousands of kilometres from a reservoir that also provides hydroelectric power to Panama City.

Decades of deforestation have reduced the ability of the environment to hold floodwaters. In order to mitigate wet and dry spells and provide additional climate and ecological benefits, the Smithsonian Tropical Research Institute has been collaborating with the Panama Canal Authority on forest restoration projects and research into the best planting techniques.

However, it could not be sufficient to fulfil the urgent need for freight through the Panama Canal. The events of this year have highlighted how urgent it is to secure additional water sources "For the next fifty years, whatever can be done within the watershed will not be sufficient."

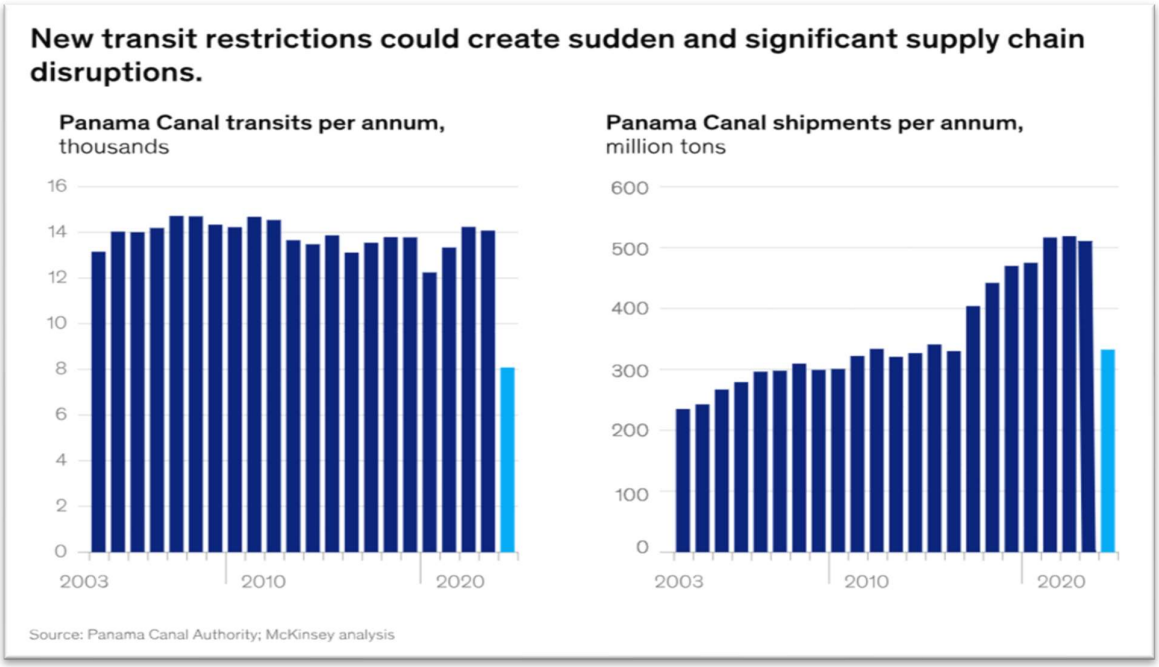

Figure 7 Panama Canal transits and shipment **Source: ACP; McKinsey analysis**

Throughout the late 20th and early 21st centuries, trade via the Panama Canal increased gradually as larger ships could carry more cargo. More freight passed through the canal in 2016 as broader locks were built to accommodate much larger ships known as "Neopanamaxes," even if the total number of transits remained virtually constant.

Now, the tonnage crossing the canal might be reduced by over one-third in less than a year. For supply networks, this would mean a sudden and major shift. It may not take long to arrange for changes to be made for all parties involved, including ship and cargo owners.

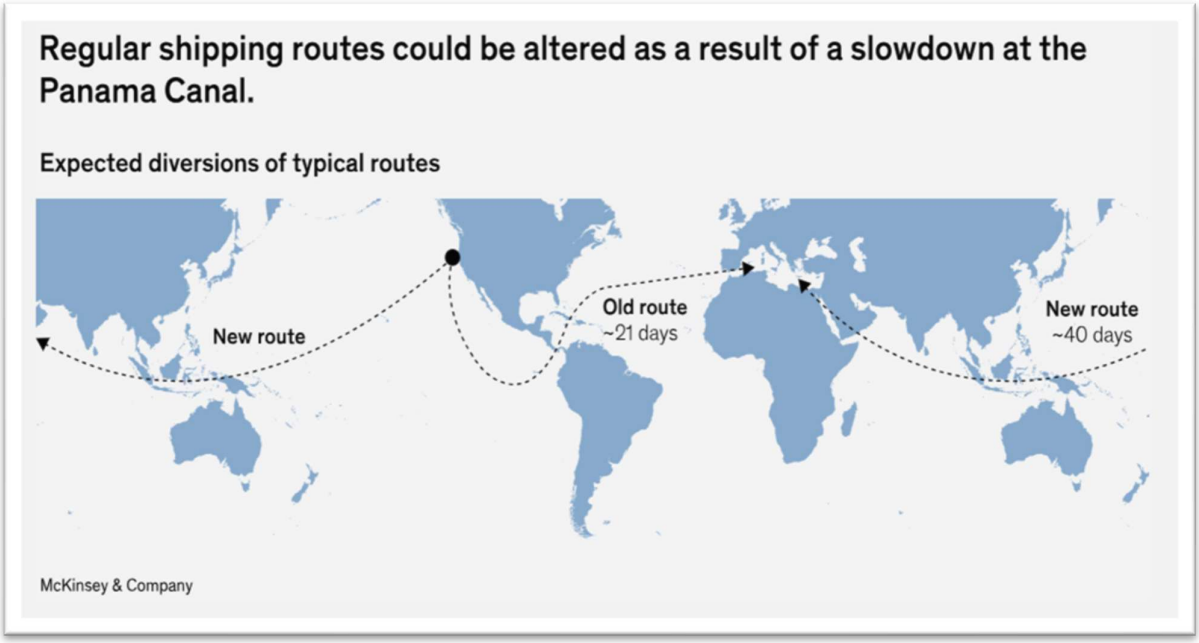

Figure 8 Altered Shipping Route **Source: McKinsey & company**

3.16 RESTRICTIONS LEADING TO DIVERTED CARGO.

Ships may choose to take an alternate path when faced with a limited number of canal transit slots. For example, a ship sailing from Asia to the Caribbean may circumnavigate the southern edge of Africa and head west, bypassing the Panama Canal, which would normally lead it east. Rather of using the Panama Canal to get from South America's west coast to the Caribbean, a ship might proceed through the Strait of Magellan, which is located at the southernmost point of the continent. Instead of going east through the Panama Canal, a ship sailing from the west coast of North America to the Mediterranean Sea may head west through the Suez Canal.

3.17 THOUSAND OF TRANSITS DIVERTED

The limits may result in over 4,000 fewer crossings of the Panama Canal. We estimate that around 2,000 yearly transits, mostly involving dry-bulk carriers and roll-on/roll-off, or ro-ro, ships, may divert from the Panama Canal to the Cape of Good Hope, located at the southern point of Africa, if trade trends stay unchanged from pre-restriction norms. There is a possibility to redirect some 1,000 dry-bulk ships and chemical tankers from Panama to the Strait of Magellan, which is located at the southernmost point of South America, on an annual basis. Ocean carriers may be less inclined to divert ships through the wider Suez Canal if they utilise the same vessels that are normally used for transits through the Panama Canal. However,

container companies may decide to move to larger ships in response to constraints on the Panama Canal. Generally, this would make Suez transits more feasible because of the bigger ships' increased cargo capacity, which makes use of the Suez's broader width, and their improved fuel economy, which lowers the cost of longer journeys. On the other hand, judgements on Suez transits may be influenced by unpredictability in the Red Sea region.

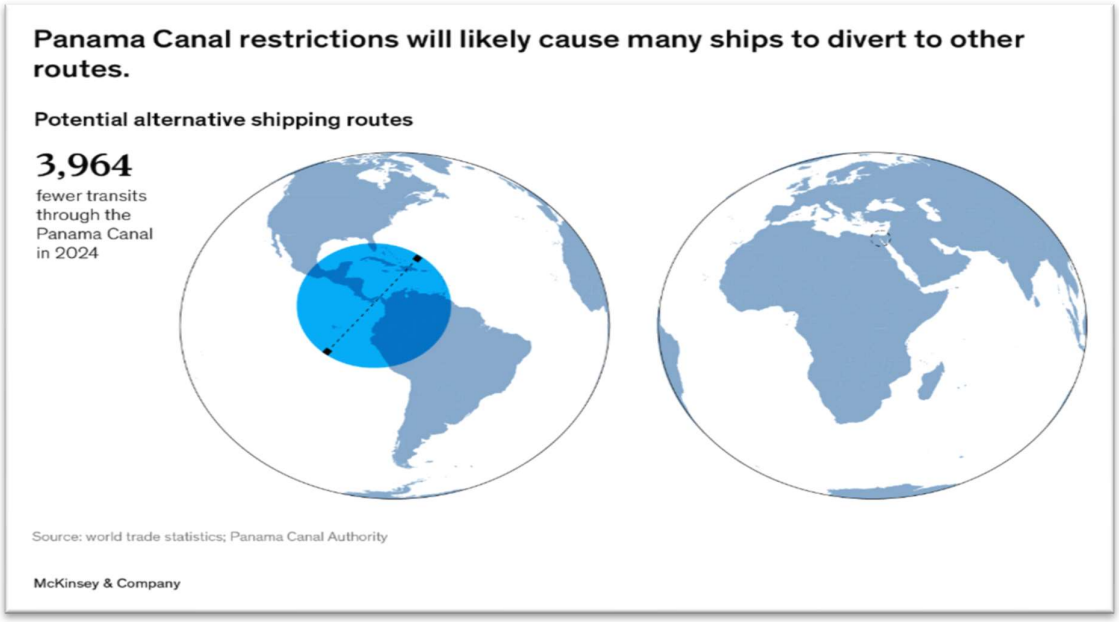

Figure 9 Potential alternate shipping route **Source: McKinsey & company**

Figure 10 Potential alternate shipping route **Source: McKinsey & company**

Figure 11 **Potential alternate shipping route** **Source: McKinsey & company**

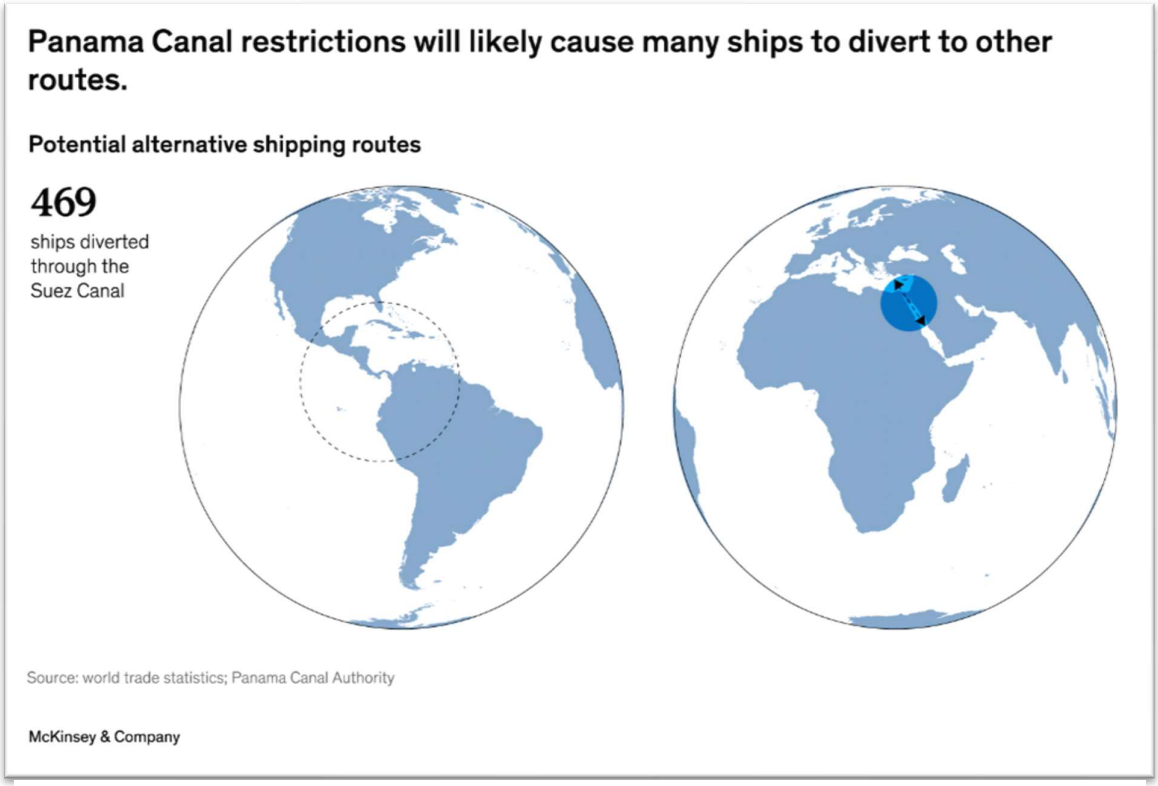

Figure 12 **Potential alternate shipping route** **Source: McKinsey & company**

3.18 CARGO DIVERSIONS COULD INCREASE TRANSPORT COSTS.

Wherever ships may divert, expenses will almost certainly rise. Longer trips are more costly (because of things like fuel consumption) and result in higher inventory-holding expenses for the cargo carried on board.

The overall maritime transport expenses of goods that now passes through the Panama Canal might rise by around 5% with new routes, amounting to an estimated $1.1 billion annually. Furthermore, these new routes are expected to slow down ship travel by almost 20%. Many ships that previously travelled the canal, which took an average of 22.6 days to reach their destinations, may choose to choose an alternative route, which would likely need an additional four days.

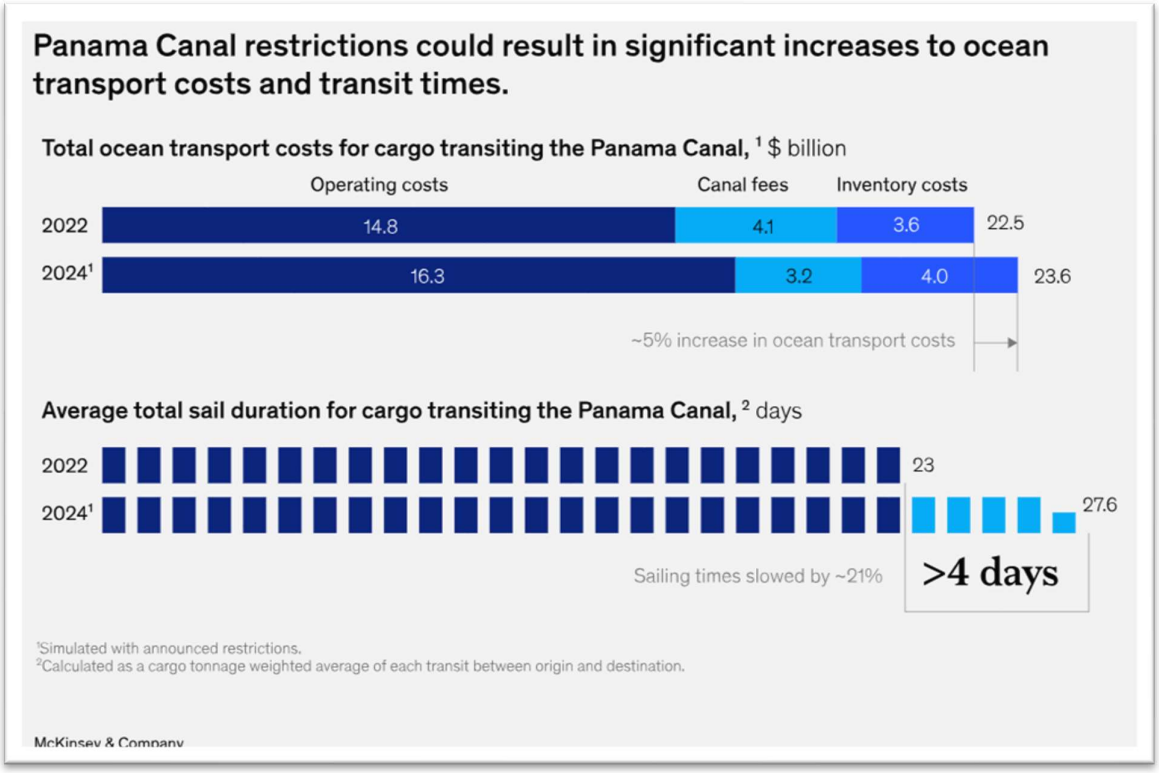

Figure 13 Increased transportation cost **Source: McKinsey & company**

3.19 COST EFFECTS COULD VARY WIDELY BY CATEGORY.

It is unlikely that all supply chains will be impacted similarly by the limitations that ACP is implementing. Due to the possible advantages of the faster travel times that the canal provides, some ships would be prepared to pay for the restricted number of canal transit slots. It could now make sense for other ships to use alternative routes in order to avoid paying canal tolls.

The majority of container ships currently pay an additional cost to utilise the priority canal transit slot reservation scheme. It's probable that they will when the new limitations take effect. Other vessels that experience comparable cost savings from speedier canal transits—such as liquefied natural gas carriers, which incur substantial operating and inventory-holding expenses—might also be prepared to pay for priority reservations, take part in the queue-buying auction process, or do both.

Since they will now need to pay more to obtain a slot, other ship types that previously typically travelled the canal without paying more for priority booking—ships with lower daily operational costs and less valuable cargo on board—may find it too expensive to utilise the canal. This group probably includes dry-bulk carriers, which transport bulk goods like coal and grains, as well as ordinary cargo ships, which transport bulky goods like wind turbines and locomotives. For every extra day at sea, a dry bulker's operational expenses are around half that of a container ship. Conversely, the value of dry bulk is often much less than that of container ship cargo. A bulker is more likely to be prepared to take a longer journey in order to avoid paying canal booking fees because of lower operational and inventory-holding expenses.

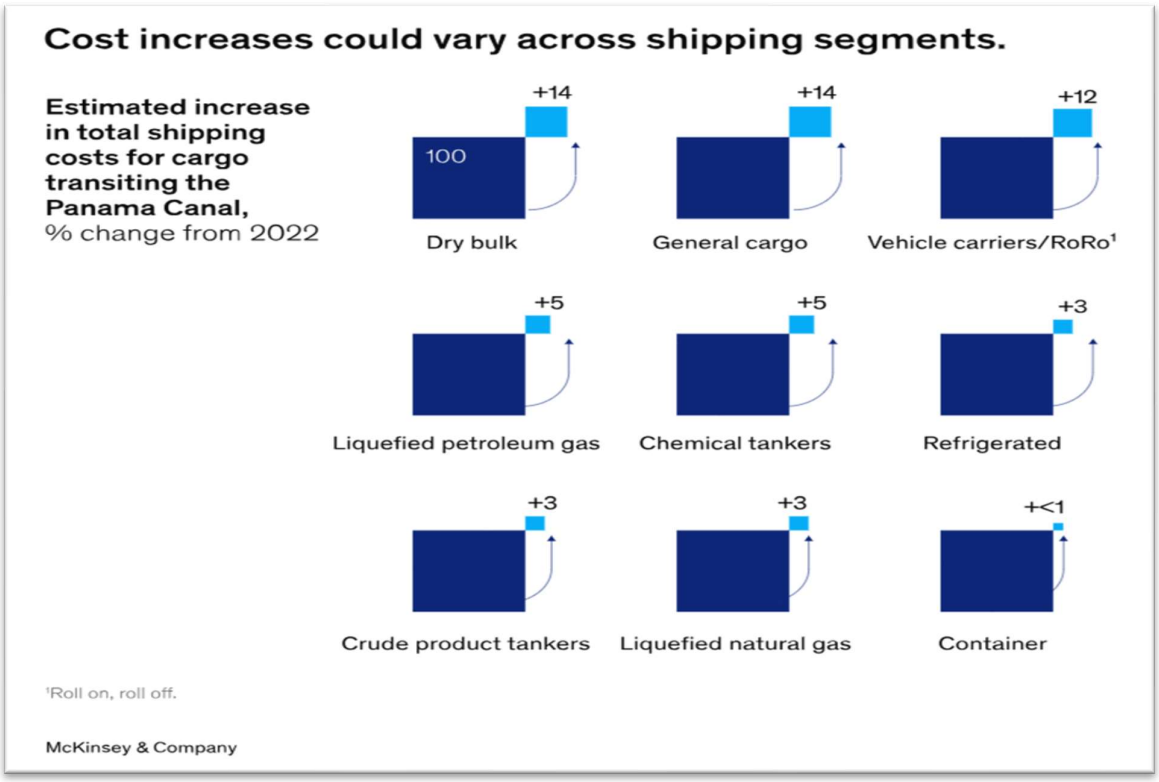

Figure 14 Estimated increase in total shipping cost **Source: McKinsey & company**

There's been doubt about whether canal activities would resume at their regular pace due to the worst drought Panama has seen in decades. Affected parties must evaluate the consequences in the meantime. The limitations of the ACP may have somewhat varied effects on various industries.

The following are a few key insights that will be significant to different stakeholders:

- Regardless of the reactions of the impacted parties, the canal limits will probably lead to an increase in costs across the board. These kinds of expenses are frequently transferred to clients, who then become the ultimate consumers.

- Overall, the disruption for tankers carrying liquefied natural gas, crude oil, and containers may be less severe than for many other shipping segments because these ships are likely to either continue using priority booking for transit slots through the Panama Canal or convert to larger vessels and use the Suez Canal.

- If the risk of spoiling precludes extended travel periods, perishable goods that would normally be transported onboard refrigerated ships might instead be transported in refrigerated containers (carried aboard container ships). This adjustment may require a significant reorganization of some supply chains, but it could be the only option available—particularly in the event that the disruption to the canal is prolonged.

- Our estimate suggests that rerouting might be necessary for around half of the transits of liquefied petroleum gas. The consequences on these US Gulf Coast shipments to Asia might result in large financial losses for all parties involved given the size of the interrupted volume.

- It might be advantageous for commodity traders to evaluate and include into their models the anticipated effects of increased expenses and longer sailing durations. Keep in mind that lengthier trips may result in larger inventory levels, which may lead to a need for additional land-based storage space.

CHAPTER - IV

4.1 ANALYSIS

Transits via the Panama Canal have decreased by about 40% from their peaks. Over the past two years, there has been a significant decrease in the number of transits via the Panama Canal.

4.2 ALMOST HALF OF THE TRANSITS IN THE TWO INTERNATIONAL CANALS

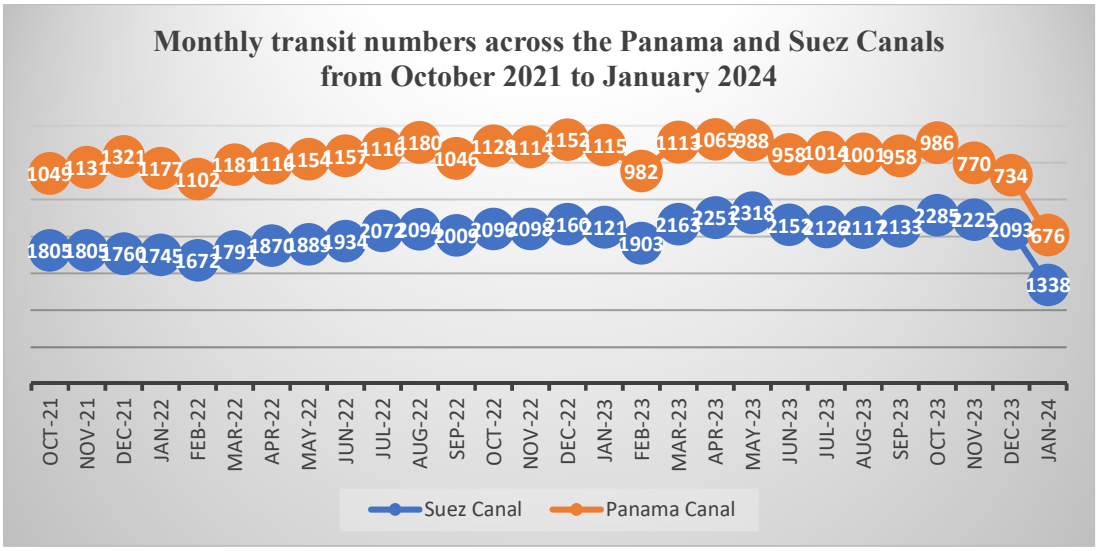

Figure 15 Monthly Transit Panama and Suez Canal Source: UNCTAD report

The Panama Canal Authority has lowered daily transits from an average of 36 to 22 due to dangerously low water levels, with plans to further cut transits to 18 daily by February 2024. The nations around South America's west coast greatly benefit from the Panama Canal.

Prior to the present Red Sea crisis, more ships were transiting the Suez Canal carrying cargo from Asia in order to avoid lengthy wait periods. Shippers no longer have the option of rerouting through the Suez Canal, which has led to an increase in demand for rail and road transport services in recent weeks due to the difficulties in the Panama Canal.

4.3 THE PANAMA CANAL'S SIGNIFICANCE FOR CERTAIN NATIONS.

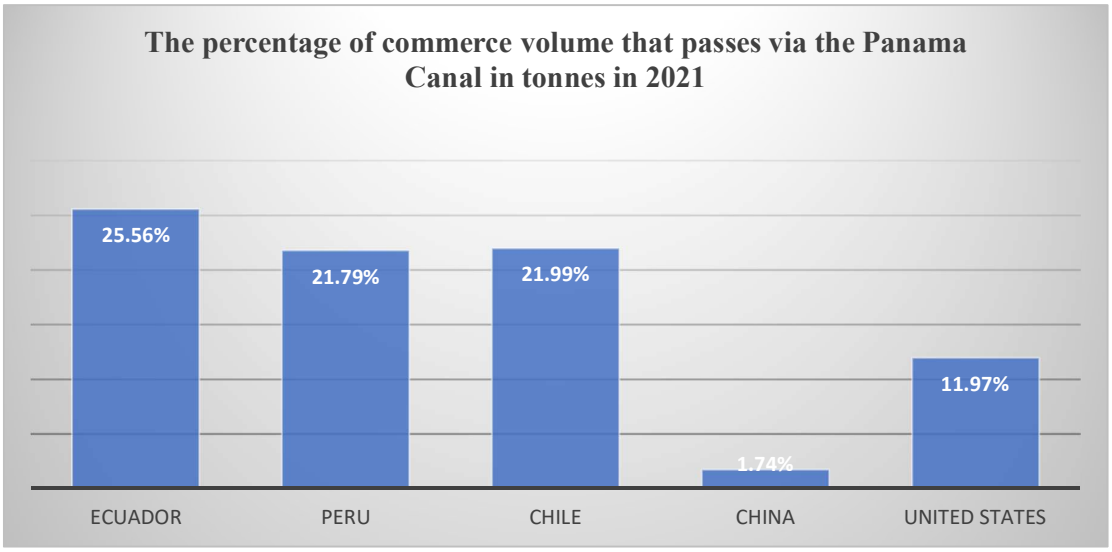

Figure 16 Percentage commerce volume **Source: UNCTAD report**

According to the most recent statistics available for the first quarter of 2024, new services, particularly those from and to Africa, are being offered in place of the Gulf nations as container shipping capacity is being reallocated.

4.4 DISRUPTIONS IN THE PANAMA CANAL, RED SEA, AND BLACK SEA INCREASE DISTANCES.

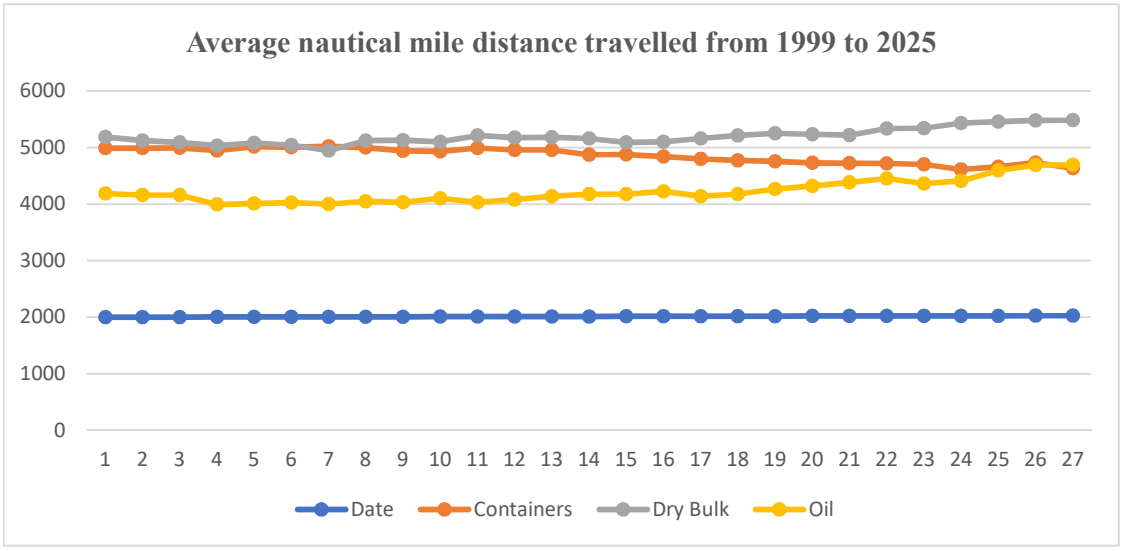

Figure 17 Average distance travelled **Source: UNCTAD REPORT**

4.5 SHIPS OPERATED BY COMPANIES ARE BEING REROUTED TO AVOID THE MIDDLE EAST.

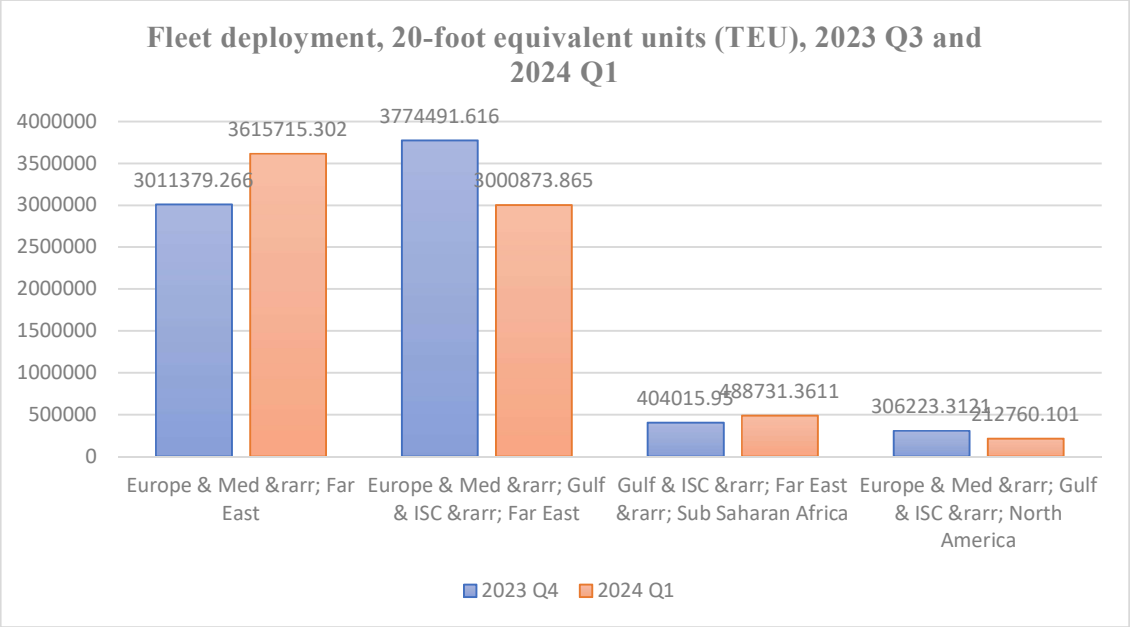

Figure 18 Fleet deployment **Source: UNCTAD REPORT**

4.6 SPEED OF VESSELS AND CARBON EMISSIONS RISE

As redirected boats increase their speeds to traverse greater distances, the environmental benefits of "slow steaming" may be undermined by variables related to the Panama Canal, the Black Sea, and the Red Sea.

This is especially true for container ships, where an increase in speed of 1% usually results in an increase in fuel usage of 2.2%. By increasing speed from 14 to 16 knots, for instance, 31% more gasoline is used per mile.

This means that rerouting from the Suez Canal to the Cape of Good Hope results in longer routes, which implies a 70% increase in greenhouse gas emissions for a round-trip from Singapore to Northern Europe.

WHEN THE RED SEA CRISIS FIRST BEGAN, VESSEL SAILING SPEED SPIKED AND THEN BEGAN TO DECLINE IN EARLY 2024.

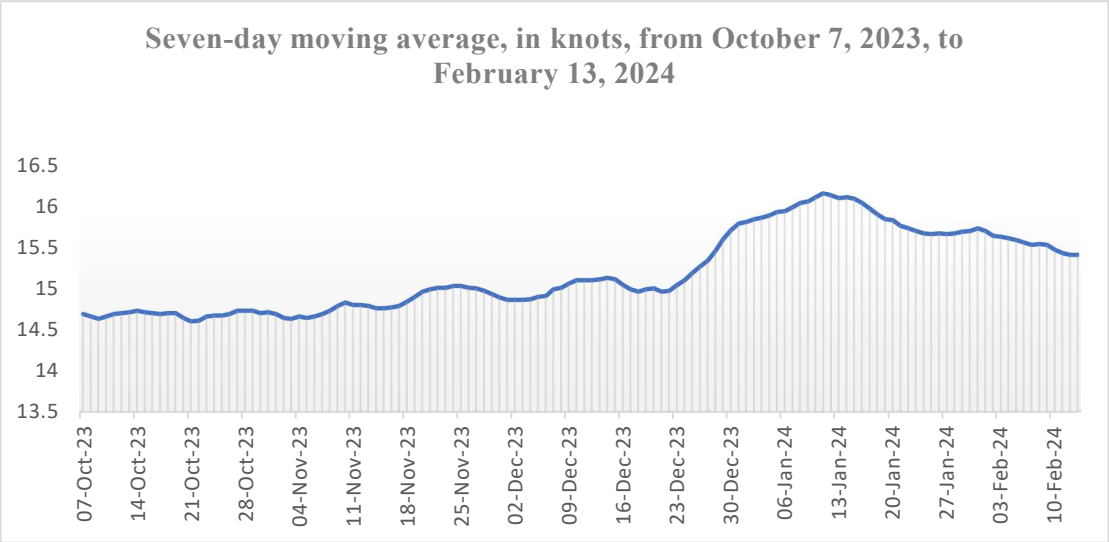

Figure 19 Spiking vessel sailing speed **Source: UNCTAD REPORT**

4.7 COSTS AND PRICES FOR SHIPPING ARE RISING.

Even if the rise in freight prices has been more pronounced on routes that cross the Suez, the effects are seen even farther away. For example, the rates on routes that connect Asia to the US West Coast have increased by 130% since early November. For travel to locations in the central and eastern regions of the United States, the West Coast offers an alternate rail route. Meanwhile, there have been fewer rises in freight rates to other destinations.

RATES FOR SHIPPING CONTAINERS ARE INCREASING ONCE MORE.

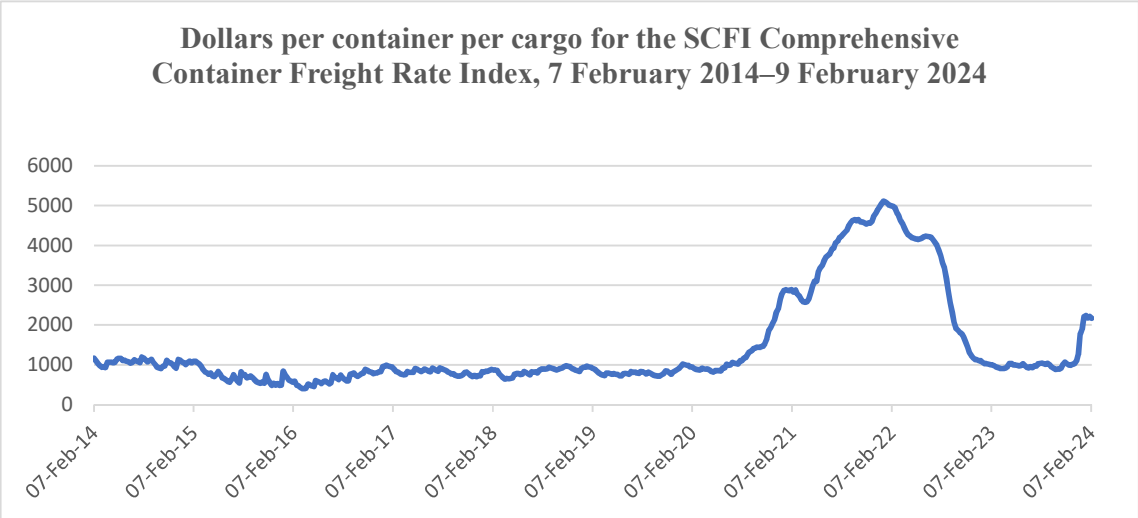

Figure 20 Increasing container rates **Source: UNCTAD REPORT**

The Panama Canal, a critical artery of global trade, faces various vulnerabilities that could lead to significant disruptions. Its geographic location makes it susceptible to natural disasters such as earthquakes and tropical storms, which can damage infrastructure and halt operations. Additionally, political instability in Panama or neighbouring countries could disrupt canal operations through protests, strikes, or even sabotage. Cyberattacks targeting the canal's control systems pose a modern threat, potentially causing chaos in navigation and logistics. As ships have grown larger over time, any accidents or blockages within the narrow confines of the canal could have cascading effects on global trade routes and supply chains. Furthermore, the canal's reliance on a single waterway heightens the risk of congestion during peak traffic, exacerbating the potential for delays and bottlenecks. Given its pivotal role in international commerce, any disruption to the Panama Canal could reverberate across industries and economies worldwide, underlining the urgent need for robust contingency plans and infrastructure resilience measures. A questionnaire is a helpful tool for compiling information about a certain subject. Chokepoint disruption, with a case study on Panama Canal, is the subject here. The purpose of the questionnaire would have been to gather data on a number of chokepoints and Panama Canal disruption related topics, like familiarisation with the recent drought affecting Panama Canal, shipment delays, detouring, alternative routes, supply chain resilience, increasing freight cost due to disruption, demand for shipping, etc. A sample of people who had experience with the port, logistics and geography, such as Mariners, shipping agent, pricing specialist, operations personnel were given the questionnaire. Data would be analysed to find patterns and trends after it was gathered. Following that, conclusions would be drawn about the cascading effects of chokepoint disruption on marine trade., including the difficulties faced by stakeholders, and potential solutions to these difficulties. Additionally, the chapter would summarise the questionnaire's results in a clear and concise manner, illuminating the information with tables, graphs, and charts. The chapter would then end with a discussion of the findings' implications for the maritime sector, including any possible gains from putting solutions to the problems that the maritime sector is facing due to chokepoint disruptions. The chapter would also suggest areas for further study on the subject of the long-term impact of disruptions at various canals. A sample of people were taken and a set of 31 questions were prepared and the questionnaire was circulated to take 100 responses from these samples.

4.8 THE FOLLOWING RESULTS WERE OBTAINED FROM QUESTIONNAIRE:

- Majority of people who participated in the questionnaire belonged to the age group of 20-30 followed by age group of 30-40. Out of the 102 responses, 69% of responses were from people belonging to 20-30 age group. No responses were obtained from people belonging to the age group of 50 and above and below 20. This indicates that most people who responded are youths who belong to the age group of 20-30.
- While 77% men responded to the questionnaire, 23% where were the share of women who responded. No other responses were obtained, and no one preferred not to reveal their gender.
- 61% of the responses comprises graduate community, whereas 29% of responses are post graduate, while 8% of the responses were from professional degree.
- There were responses from unique background like 25.5% logistics manager, 19.6% mariners, 17.6% freight forwarder, 11.8% charterers and 8.8% each port manager and pricing specialist giving insights from distinct domain of knowledge.
- Majority have experience between 1-5 years 63.7% while 19.6% have less than 1year experience and 14.7% have 6-10 years of experience.
- While responding to whether they are familiar with the recent drought affecting Panama Canal, 47.1% were moderately familiar, while 36.3% were somewhat familiar and 10.8% were very familiar.

FAMILIAR WITH RECENT DROUGHT IMPACTING PANAMA CANAL

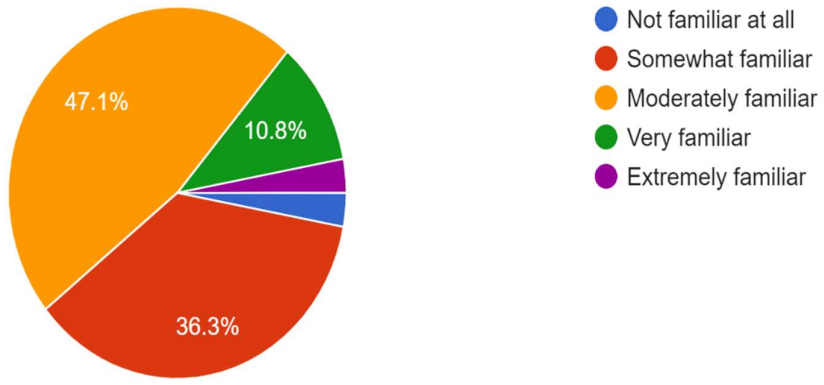

Figure 21 Drought familiarisation **Source: Questionnaire Analysis**

Regarding delays in shipments due to the Panama Canal situation and days of delays per shipment 85.3% respondents encountered delays out of which 49% had 1-3 days delay, 48% had 4-7 days delay and 3% had more than 7days delay per shipment delivered.

DELAYS IN SHIPMENTS DUE TO THE PANAMA CANAL SITUATION

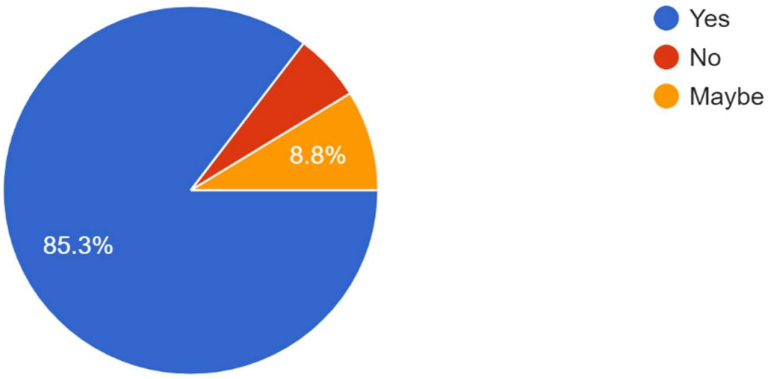

Figure 22 Delays in Shipment **Source: Questionnaire Analysis**

DAYS OF DELAYS PER SHIPMENT

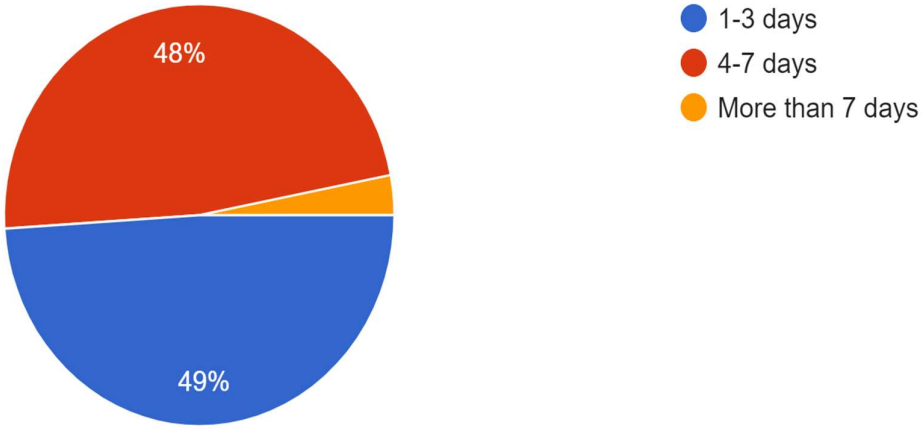

Figure 23 Days of delays ***Source:* Questionnaire Analysis**

For the question related to what alternative routes considered 76.5% respondents preferred Cape Horn route and 23.5% chose Suez Canal, while 8% considered Artic route.

With reasons to consider alternative routes 72.5% chose to avoid congestion at Panama Canal, 30% said increased toll due to drought, while 9.8% were having safety concerns due to low water levels.

WHAT ALTERNATIVE ROUTES CONSIDERED

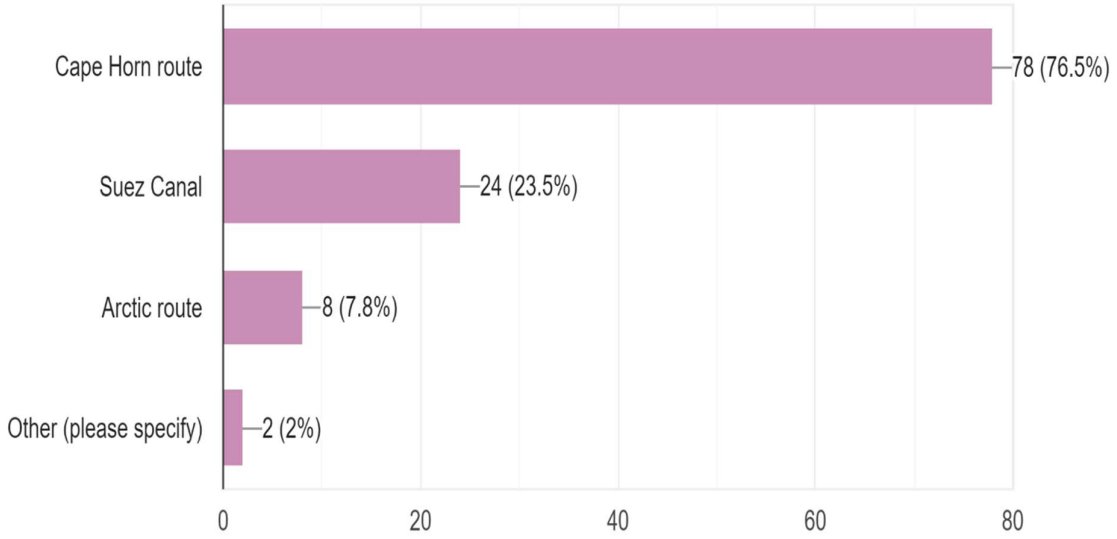

Figure 24 Alternatives routes considered **Source: Questionnaire Analysis**

REASONS FOR CONSIDERING ALTERNATIVE ROUTES

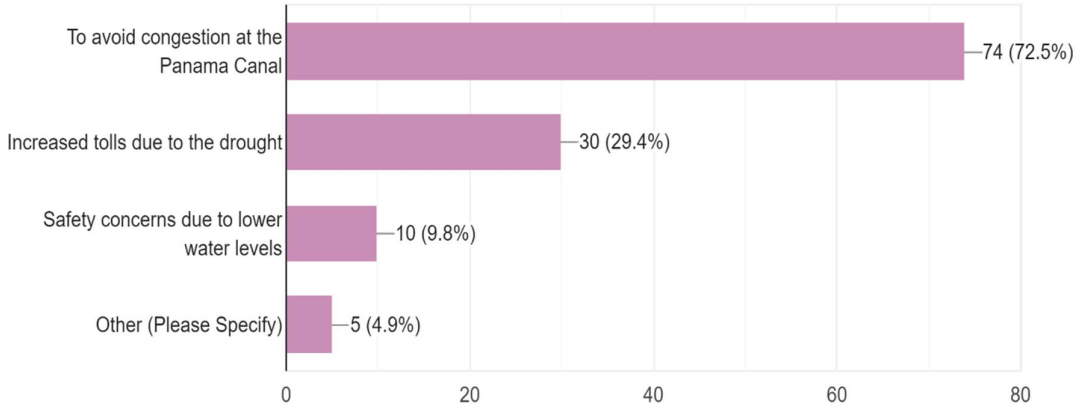

Figure 25 Reasons for alternative routes ***Source:* Questionnaire Analysis**

Responding to how changing shipping routes impacted overall voyage time for cargo movements 72.5% chose it increased moderately by 10-20%, while 10.8% respondents acknowledged it increased significantly by more than 20% and 16.7% answered minimal increase by less than 10%.

HOW CHANGING SHIPPING ROUTES IMPACTED OVERALL VOYAGE TIME FOR CARGO MOVEMENTS

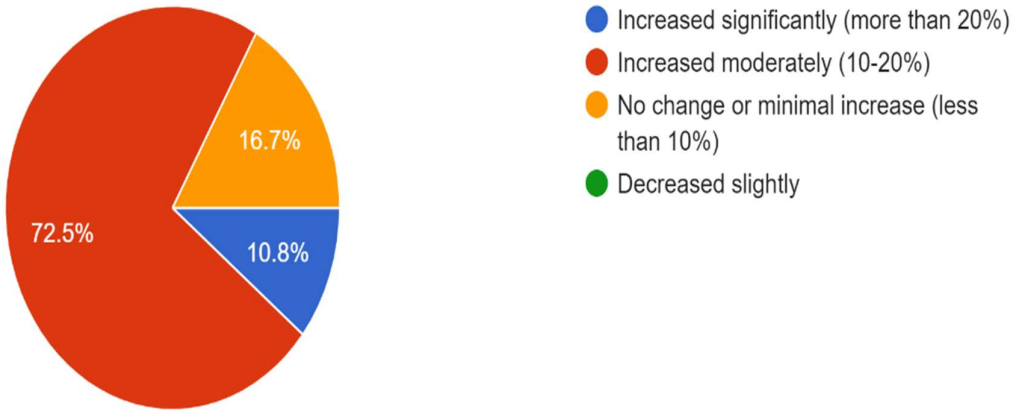

Figure 26 Overall voyage time impact ***Source:* Questionnaire Analysis**

For the question has the recent drought in Panama Canal affected shipping operations 73.5% said yes and 13.7% said no further asking how would you describe overall impact of Panama Canal situation on shipping operations 50% said moderate negative impact and 45.1% said minor negative impact.

RECENT DROUGHT IN PANAMA CANAL AFFECTING SHIPPING OPERATIONS

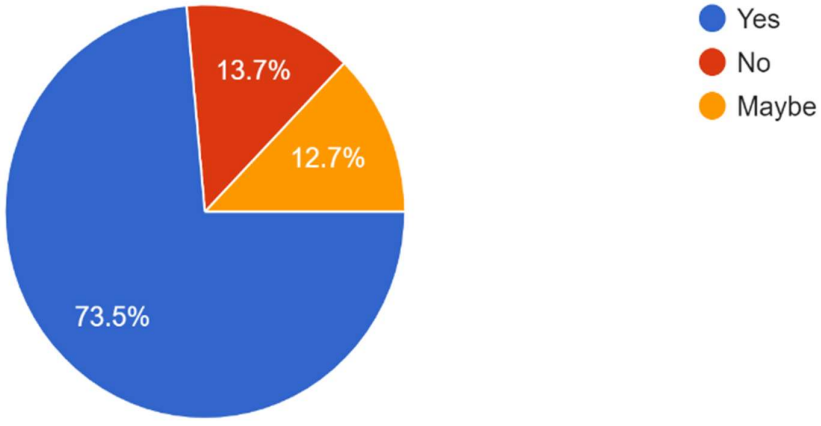

Figure 27 Drought affecting shipping operation ***Source:* Questionnaire Analysis**

DESCRIBE OVERALL IMPACT OF PANAMA CANAL SITUATION ON SHIPPING OPERATIONS

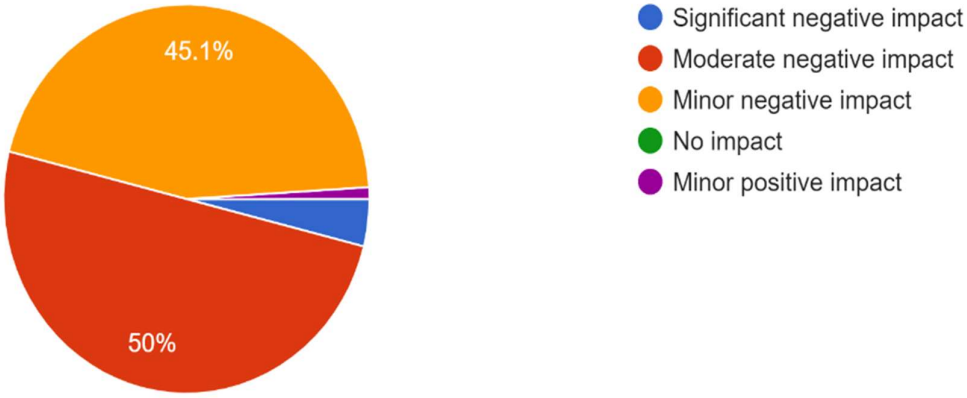

Figure 28 Overall impact on shipping operation *Source:* **Questionnaire Analysis**

With questions have freight costs for goods transported through the Panama Canal fluctuated since the drought began 46.1% each said yes, moderately increased and yes, slightly increased. With estimation on the average percentage increase in freight costs observed 62.5% said 5-10% increment whereas 12.7% answered 11-15% increment and few said less than 5% increment in freight cost.

HAVE FREIGHT COSTS FOR GOODS TRANSPORTED THROUGH THE PANAMA CANAL FLUCTUATED SINCE THE DROUGHT BEGAN

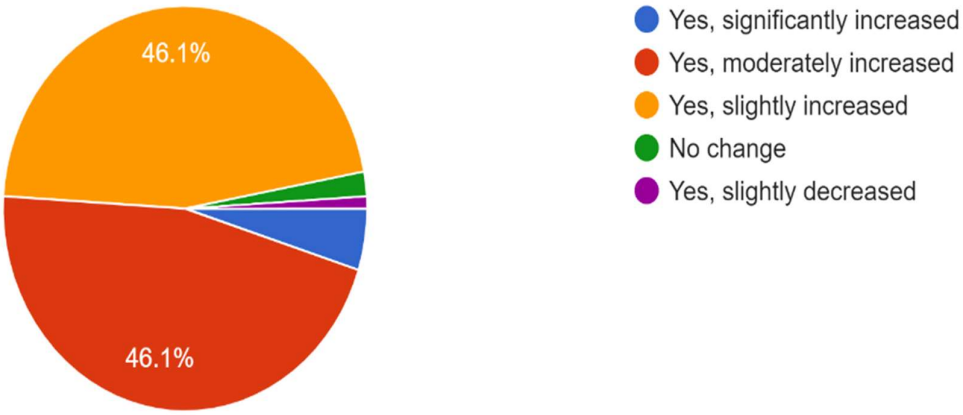

Figure 29 Freight cost fluctuations *Source:* **Questionnaire Analysis**

ESTIMATION ON THE AVERAGE PERCENTAGE INCREASE IN FREIGHT COSTS OBSERVED

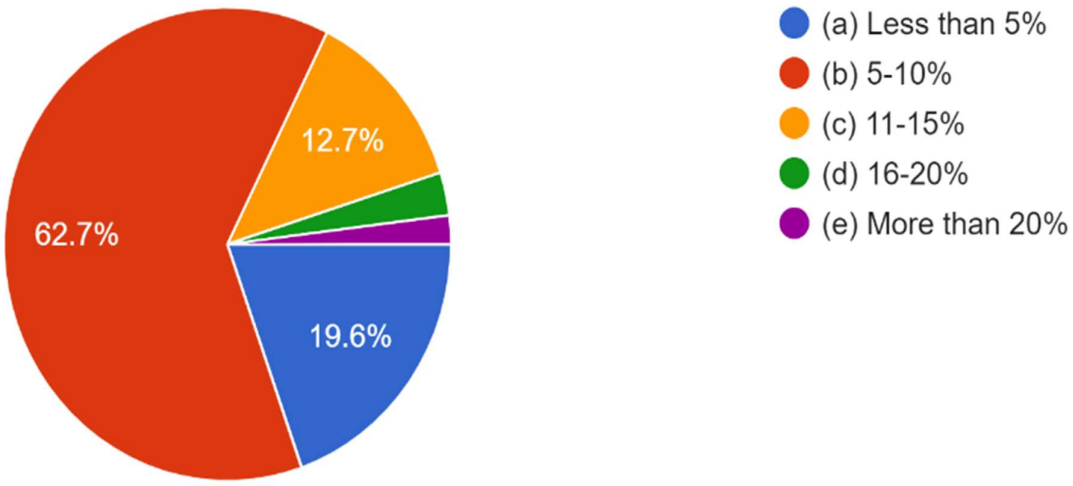

Figure 30 Average % increase in freight cost ***Source:*** **Questionnaire Analysis**

4.9 MONTHLY FIGURES FOR OCEANGOING COMMERCIAL TRAFFIC ACROSS THE PANAMA CANAL (FY 2020–2023)

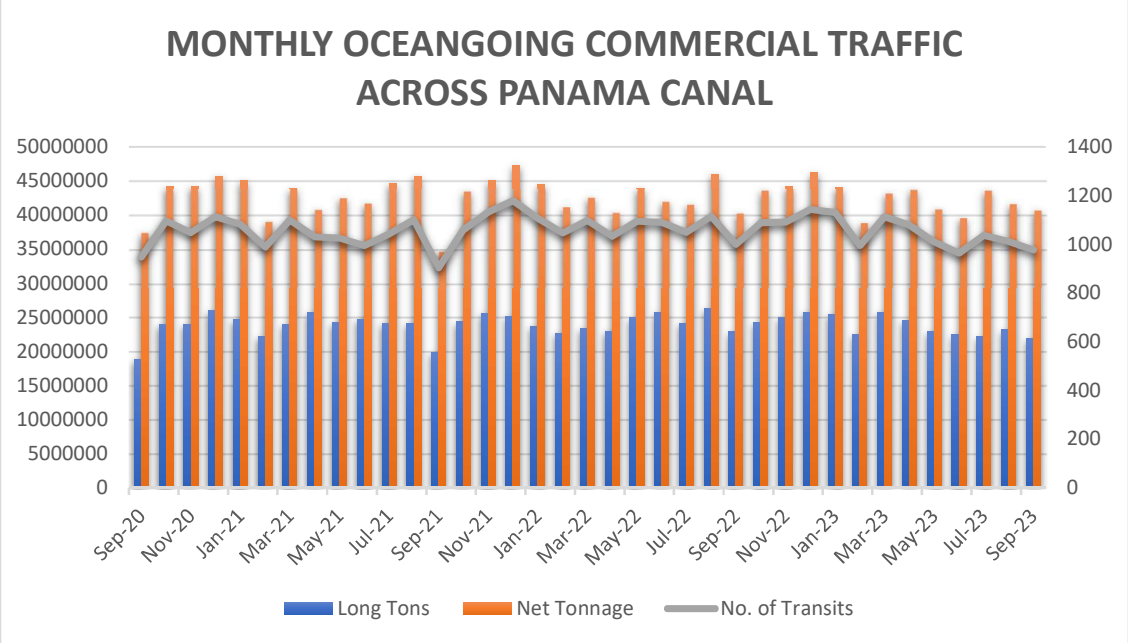

Figure 31 Monthly Commercial Traffic Source: **Panama Canal. Statistics and Models Management Unit (MEEM)**

Container carriers accounted for 2,787 ships during the fiscal year 2023, followed by bulk carriers with 2,649 ships and chemical tankers with 2,196 transits. These three market segments account for the majority of oceangoing vessel traffic. These market categories' involvement accounted for 22%, 20.9%, and 17.4% of all transits, respectively.

4.10 PANAMA CANAL TRAFFIC BY MARKET SEGMENT FISCAL YEARS 2023-2022

The title of the image is "Panama Canal Traffic by Market Segment Fiscal Years 2023-2022". This table shows the number of transits, cargo tonnage and the percentage increase or decrease of traffic through the Panama Canal, segmented by market segment, for fiscal years 2023 and 2022.

Overall, the total number of transits decreased by 2.81% from 2022 to 2023. There were also decreases in net cargo tonnage (1.51%) and and the tonnage of most market segments.

Here are some specific observations about the data for fiscal years 2023 and 2022:

- The number of container ship transits decreased by 1.24% from 2,822 in 2022 to 2,787 in 2023. This segment also saw a decrease in net cargo tonnage of 1.87%.
- Dry bulk carriers saw the steepest decline in both transits (8.97%) and net cargo tonnage (11.79%)
- Liquefied natural gas (LNG) also saw a significant decrease in both transits (12.83%) and net cargo tonnage (9.75%)
- The number of liquefied petroleum gas (LPG) transits increased by 17.06%, and net cargo tonnage increased by 17.37%. This was the only market segment to see an increase in both categories.
- Passenger transits increased significantly by 88.98%, however the number of transits in both years (240 in 2023 and 127 in 2022) is very small compared to other segments.

PANAMA CANAL TRAFFIC BY MARKET SEGMENT FISCAL YEARS 2023-2022

Market Segment	Number of Transits		Net Cargo Tonnage (Thousands)		Percentage of Increase or Decrease	
	Year 2023	Year 2022	Year 2023	Year 2022	Transits	Cargo Tons
Chemical Tankers	2196	2332	48825	52186	▼5.83%	▼6.44%
Container	2787	2822	192760	196426	▼1.24%	▼1.87%
Crude Product Tankers	499	607	16052	20432	▼17.79%	▼21.44%
Dry Bulk	2649	2910	74549	84509	▼8.97%	▼11.79%
General Cargo	519	645	6655	8261	▼19.53%	▼19.44%
Liquefied Natural Gas	326	374	37001	41000	▼12.83%	▼9.75%
Liquefied Petroleum Gas	1757	1501	64969	55355	▲17.06%	▲17.37%
Other	306	335	1718	1588	▼8.66%	▲8.19%
Passengers	240	127	12361	7099	▲88.98%	▲74.12%
Refrigerated	546	604	5610	5854	▼9.60%	▼4.17%
Vehicle Carriers/Ro-Ro	813	706	49871	45461	▲15.16%	▲9.70%
Total	**12638**	**13003**	**510370**	**518171**	▼2.81%	▼1.51%

Table 2 Panama Canal Traffic 22-23 **Source: Self Tabulated Data from ACP**

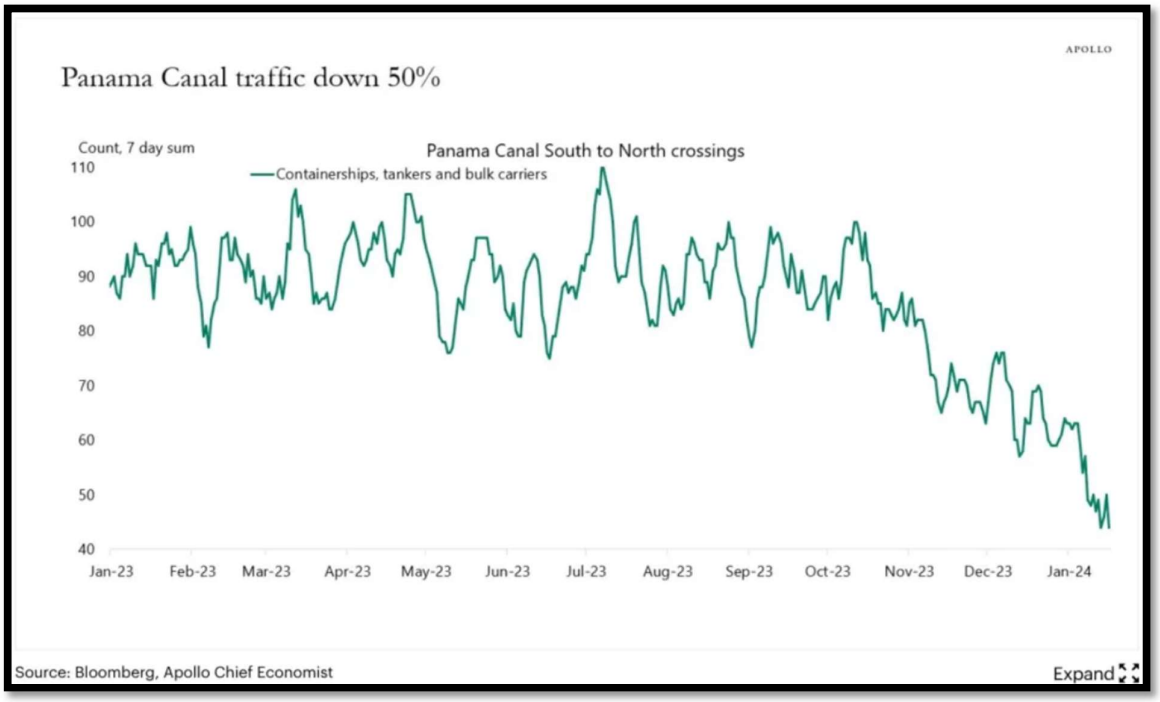

Figure 32 Panama Canal Traffic Graph **Source: Bloomberg, Apollo Chief Economist**

4.11 FINDINGS:

Here are the key findings derived from the analysis of the data:

- Majority of respondents fell within the age group of 20-30 years, indicating a strong representation of youth in the maritime sector's perspective on Panama Canal disruptions.
- There was a notable gender disparity, with 77% of respondents being male and 23% female, suggesting a gender imbalance in the field.
- The educational background of respondents varied, with a majority holding graduate degrees, followed by postgraduates and professionals, indicating a diverse pool of knowledge and expertise.
- The respondents represented various roles within the maritime industry, including logistics managers, mariners, freight forwarders, charterers, port managers, and pricing specialists, highlighting the multidisciplinary nature of the sector.
- The majority of respondents had relatively limited experience in the industry, with 63.7% having 1-5 years of experience.
- A significant portion of respondents (47.1%) were moderately familiar with the recent drought affecting the Panama Canal, indicating a reasonable level of awareness within the industry.
- The Panama Canal situation led to significant delays in shipments, with 85.3% of respondents experiencing delays, primarily ranging from 1 to 7 days per shipment.
- The preferred alternative route for most respondents was the Cape Horn route (76.5%), driven by the desire to avoid congestion at the Panama Canal and concerns about increased tolls due to drought.
- Changing shipping routes resulted in moderate increases in overall voyage time for cargo movements, with 72.5% of respondents reporting a 10-20% increase.
- The recent drought in the Panama Canal had a notable impact on shipping operations, with 73.5% of respondents affirming its effect, primarily describing it as a moderate or minor negative impact.
- Freight costs for goods transported through the Panama Canal increased since the drought began, with 46.1% of respondents indicating moderate increases and an average percentage increase of 5-10%.
- Container carriers constituted the largest market segment with 2,787 transits during fiscal year 2023, followed by bulk carriers and chemical tankers.

- Overall, there was a decrease in total transits by 2.81% from 2022 to 2023, along with declines in net cargo tonnage and tonnage across most market segments.
- Specific observations revealed decreases in container ship transits and net cargo tonnage, steep declines in dry bulk carriers, and liquefied natural gas (LNG) transits, while liquefied petroleum gas (LPG) saw increases in both categories.
- Passenger transits increased significantly by 88.98%, albeit from a small base, indicating a niche but growing segment of traffic through the canal.
- Impact of Drought on Panama Canal Operations: The severe drought in the region, exacerbated by El Niño, has led to record-low water levels in Gatun Lake, significantly limiting the number of ships able to navigate the canal. This has resulted in a reduction of daily traffic by over 40%, affecting global trade routes and causing ships to detour, raising expenses and carbon emissions.
- Climate Change and Water Management: Climate change has made rainfall patterns less predictable, impacting the availability of water for canal operations. Rising temperatures contribute to increased evaporation from reservoirs, exacerbating water shortages. The Panama Canal Authority faces challenges in managing water resources to meet both canal operations and the needs of the growing population, highlighting the need for long-term solutions.
- Alternative Shipping Routes and Cost Implications: Restrictions on canal transit could lead to diverted cargo, with ships opting for alternative routes such as the Cape of Good Hope or the Suez Canal. However, these routes entail longer travel distances and increased costs, potentially raising maritime transport expenses by around 5% annually and slowing down ship travel by almost 20%.
- Industry-Specific affects: Different shipping segments may be affected differently by canal limitations. Tankers carrying liquefied natural gas, crude oil, and containers may face less severe disruptions due to priority booking or conversion to larger vessels. However, rerouting of shipments, particularly for perishable goods and liquefied petroleum gas, could result in significant financial losses and require supply chain reorganization.
- Supply Chain and Trade Considerations: The disruptions in canal operations necessitate evaluation and adjustments in supply chain strategies. Commodity traders need to consider increased expenses and longer sailing durations, which may lead to larger inventory levels and the need for additional storage space. Adaptation to these changes is crucial for minimizing the impact on global trade networks.

These findings underscore the multifaceted impact of Panama Canal disruptions on the maritime industry, ranging from operational challenges such as delays and increased costs to broader implications for trade routes and market dynamics. They provide valuable insights for stakeholders in understanding the complexities of navigating through chokepoint disruptions and the importance of resilience and contingency planning in global supply chains.

CHAPTER - V

5.1 SUGGESTIONS:

Here are some suggestions we could derive from the analysis of my research:

1. Investment in Infrastructure Resilience:

- Given the vulnerabilities of the Panama Canal to natural disasters and its narrow confines, there's a critical need for infrastructure upgrades and maintenance to mitigate risks.
- Propose allocating funds towards reinforcing canal infrastructure against seismic events and tropical storms, and improving navigation systems to prevent accidents and congestion.

2. Diversification of Trade Routes:

- Encourage stakeholders to explore alternative routes such as the Cape Horn route, especially in times of canal disruptions.
- Suggest incentivizing the use of alternative routes through toll adjustments or subsidies to reduce reliance solely on the Panama Canal.

3. Environmental Considerations:

- Highlight the environmental implications of increased vessel speeds and longer routes due to canal disruptions.
- Advocate for the adoption of environmentally friendly practices such as slow steaming and investing in cleaner propulsion technologies to mitigate carbon emissions.

4. Supply Chain Resilience:

- Emphasize the importance of enhancing supply chain resilience by diversifying transportation modes and exploring multimodal solutions.
- Recommend collaborating with rail and road transport providers to improve connectivity and flexibility in cargo movements, especially during canal disruptions.

5. Policy and Regulatory Measures:

- Propose the implementation of robust contingency plans and regulatory frameworks to address potential disruptions at the Panama Canal.
- Advocate for international cooperation and agreements to streamline crisis management protocols and ensure smooth operations during emergencies.

6. Data-Driven Decision Making:

- Highlight the significance of data analytics and forecasting in predicting canal disruptions and optimizing shipping routes.
- Encourage stakeholders to leverage advanced technologies such as AI and machine learning to analyze historical data and predict future trends in canal traffic and disruptions.

7. Capacity Building and Training:

- Recommend investing in workforce development programs to enhance skills and capabilities in maritime logistics and operations.
- Emphasize the importance of training personnel in crisis management and emergency response to minimize disruptions and ensure swift recovery.

8. Public-Private Partnerships:

- Advocate for collaborative efforts between the public and private sectors to address challenges and promote innovation in canal management and operations.
- Encourage the establishment of joint ventures and partnerships to fund infrastructure projects and improve canal efficiency and resilience.

9. Promotion of Risk Awareness:

- Stress the importance of raising awareness among stakeholders about the potential risks and impacts of canal disruptions on global trade.
- Recommend educational campaigns and workshops to inform shippers, carriers, and policymakers about contingency planning and risk mitigation strategies.

10. Long-Term Planning and Adaptation:

- Urge stakeholders to adopt a long-term perspective in planning and adapting to evolving challenges and disruptions at the Panama Canal.
- Advocate for ongoing monitoring and evaluation of canal operations and performance to identify emerging risks and opportunities for improvement.

These suggestions encompass a comprehensive approach to addressing the challenges posed by disruptions at the Panama Canal, aiming to enhance resilience, sustainability, and efficiency in global maritime trade.

5.2 CONCLUSION

Despite environmental problems, the Panama Canal, a vital component of international marine trade, continues to exhibit resilience and flexibility. It guarantees the smooth passage of trade between the Americas and Asia as one of the most important transcontinental rivers. Recent evaluations, which include observations from Gibson Shipbrokers, emphasise the proactive steps the canal has taken to adapt to changing water levels brought on by climatic variability.

An essential element of the canal's architecture, Lake Gatun's water levels, has been impacted by climate dynamics, namely the El Niño event. The Panama Canal Authority (ACP) has skilfully handled the issue in spite of these difficulties, guaranteeing operating effectiveness and reducing interruptions. As the year goes on, it is anticipated that the average water level for February will rise to 80.3 feet, according to current statistics.

When combined with anticipated precipitation, the El Niño effect—which is anticipated to end by mid-2024—signals a constructive change in the direction of stabilising water levels. A further factor supporting this shift is the possible arrival of La Niña, which is expected to increase precipitation and improve drought conditions.

The ACP has put strategic measures in place to respond to these environmental variations, such as modifying transit timetables and auction bid procedures. These initiatives have successfully controlled the canal's capacity, demonstrating an adaptable tactic that lessens the influence on transit expenses and delays. The canal's operational robustness is exemplified by the recent decline in average winning bids for canal transits, which dropped from over $600,000 to just over $200,000 in the first quarter.

For the marine sector, the Panama Canal continues to be an essential route, especially for product, chemical, and crude oil vessels. Transit limits have been faced, but the sector has skilfully negotiated these obstacles, maximising routes and timetables to keep supply chains running smoothly. With the strategic planning of the canal and the anticipated weather improvements by mid-2024, there is potential for further stabilising transit operations.

The canal's dedication to sustainability and operational efficiency is demonstrated by this adaption phase, which guarantees its continued importance as a key component of international

trade. In addition to addressing today's environmental issues, the primitive steps and continuous infrastructure improvements also set the stage for future resilience against climate unpredictability.

The Panama Canal's experience navigating these environmental obstacles emphasises both its crucial position in international marine traffic and its unwavering dedication to operational sustainability and resilience. Looking ahead, the canal's innovative approaches and improvements to its infrastructure will solidify its status as an essential conduit in the world of international trade.

5.3 SCOPE FOR FUTURE OUTLOOK

The Isthmus of Tehuantepec Interoceanic Corridor (CIIT) and the Arctic Route represent significant developments in global trade and transportation infrastructure.

5.3.1 ISTHMUS OF TEHUANTEPEC INTEROCEANIC CORRIDOR (CIIT):

1. Development Initiatives: The CIIT aims to establish 11 industrial parks (Development Poles) with essential utilities and infrastructure such as fiber optics, natural gas, water, and electricity. It also includes the construction of three airports and highways for better transportation connectivity.

2. Infrastructure Modernization: Efforts are underway to modernize and expand the Salina Cruz and Coatzacoalcos ports to accommodate larger vessels. Additionally, a new highway access is being constructed in Coatzacoalcos to improve connectivity.

3. Projected Impact: Upon completion, CIIT is expected to handle a significant volume of containers annually, offering a more efficient route for international trade between the Pacific and Atlantic oceans. It aims to complement the Panama Canal and alleviate some of its traffic congestion.

5.3.2ARCTIC ROUTE:

1. Description: The Northwest Passage offers a shorter route between Europe and Eastern Asia, as well as expedited transport of Alaskan oil to the Eastern United States and North Canada's mineral resources. It passes through the waters of Canada, the United States, and Greenland.

2. Current Status: The route is becoming increasingly viable due to climate change, with a record number of transits occurring in recent years. Icebreaker escorts are currently required for navigation, but the passage may soon be navigable for all vessels during the summer months.

3. Projected Impact: Utilizing the Northwest Passage could significantly reduce travel distances and time for shipping between East Asia and America's East Coast compared to the Panama Canal. It offers savings in fuel, time, and CO2 emissions, as well as the potential to increase cargo capacity per transit due to fewer size and depth constraints.

Overall, both the CIIT and the Arctic Route represent ambitious infrastructure projects with the potential to reshape global trade routes, enhance connectivity, and drive economic growth. They offer alternative options to existing routes, addressing challenges such as congestion and environmental concerns while unlocking new opportunities for trade and development.

5.4 AREAS OF FUTURE CONCERN

1. Infrastructure Development and Economic Impact Assessment:

Investigating the economic impact of infrastructure development projects like the Isthmus of Tehuantepec Interoceanic Corridor (CIIT) in Mexico. This includes analyzing the investment returns, job creation potential, and overall contribution to the national and regional economy. Moreover, assessing the effectiveness of CIIT in enhancing international trade and connectivity by comparing it with existing routes like the Panama Canal and potential alternatives such as the Arctic Route.

2. Environmental Implications and Sustainability:

Examining the environmental implications of large-scale infrastructure projects like CIIT and the Arctic Route. This involves assessing the impact on local ecosystems, biodiversity, and natural resources. Additionally, exploring strategies for mitigating potential environmental risks and promoting sustainability in infrastructure development, including the use of green technologies and adherence to international environmental standards.

3. Climate Change Adaptation and Resilience:

Investigating the role of climate change in shaping the viability and feasibility of transportation routes like the Northwest Passage. This includes studying historical trends in Arctic ice melt,

projecting future scenarios, and assessing the implications for maritime navigation. Furthermore, exploring adaptive strategies for infrastructure development and transportation planning to mitigate the effects of climate change and enhance resilience to environmental variability.

4. Geopolitical Dynamics and International Relations:

Analysing the geopolitical implications of emerging transportation routes such as the Arctic Route in the context of shifting global power dynamics. This involves examining the interests and strategies of key stakeholders, including Arctic littoral states, major shipping nations, and international organizations. Additionally, assessing the potential for cooperation and competition among states in the Arctic region and its impact on global trade and security.

5. Technological Innovation and Infrastructure Optimization:

Exploring opportunities for technological innovation and optimization in transportation infrastructure, including the use of advanced logistics systems, digitalization, and automation. This involves studying best practices from existing transportation corridors like the Panama Canal and identifying areas for improvement in terms of efficiency, safety, and reliability. Furthermore, examining the potential for integrating emerging technologies such as artificial intelligence, blockchain, and autonomous vehicles into future infrastructure projects.

6. Risk Management and Contingency Planning:

Assessing the risks associated with alternative transportation routes, including geopolitical instability, natural hazards, and technological disruptions. This includes developing risk management strategies and contingency plans to mitigate potential threats to maritime navigation and supply chain operations. Moreover, exploring mechanisms for international cooperation and coordination in responding to emergencies and crisis situations in critical transportation corridors.

7. Social and Cultural Impacts:

Investigating the social and cultural impacts of infrastructure development projects on local communities and indigenous populations. This involves assessing issues related to land rights, displacement, cultural heritage preservation, and social equity. Additionally, exploring strategies for community engagement, capacity building, and inclusive development to ensure

that infrastructure projects benefit all stakeholders and promote sustainable socio-economic development.

8. Policy Analysis and Regulatory Frameworks:

Analyzing the policy frameworks and regulatory mechanisms governing international transportation routes and infrastructure development. This includes studying relevant treaties, agreements, and conventions, as well as national legislation and regulatory practices. Moreover, assessing the effectiveness of existing governance structures in addressing emerging challenges and facilitating cooperation among states, private sector actors, and civil society organizations in managing global transportation networks.

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