IMPACT OF CLIMATE CHANGE ON MARINE INDUSTRY

by

Keshwini.S, MBA, BBA.

DISSERTATION

Presented to the Swiss School of Business and Management Geneva

In Partial Fulfillment

Of the Requirements

For the Degree

DOCTOR OF BUSINESS ADMINISTRATION

SWISS SCHOOL OF BUSINESS AND MANAGEMENT GENEVA

APRIL 2024

IMPACT OF CLIMATE CHANGE ON MARINE INDUSTRY

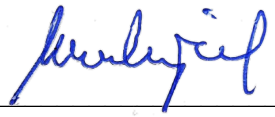
by

Keshwini. S

Supervised by

Dr. Anna Provodnikova

APPROVED BY

Dr. Jaka Vadnjal 

Dissertation chair

RECEIVED/APPROVED BY:

_____

Admissions Director

Dedication

Dedicated to my parents, S. Hemalatha, D. Sukumar and to my family members and to my close friend N. Lavanya, who helped and supported me throughout the journey.

And to my mentor Dr. Anna Provodnikova who is very kind towards me throughout the journey.

Acknowledgements

Special thanks to my mentor Dr. Anna Provodnikova for her guidance, advice and support.

ABSTRACT

IMPACT OF CLIMATE CHANGE ON MARINE INDUSTRY

Keshwini.S

2024

Dissertation Chair: <Chair's Name>

Co-Chair: <If applicable. Co-Chair's Name>

Sea level rise, coastal erosion, agricultural production, oil transportation interruptions, and maritime transportation are just a few of the many facets of climate change that this research explores. The study collected a substantial volume of data from a variety of sources and points of view by using a mixed-methods strategy that included quantitative and qualitative techniques. The maritime industry's stakeholders were surveyed and interviewed to provide primary data, which was supplemented by secondary data culled from literature reviews and previous studies. The study's findings, derived from a sample of 300 participants, provide insight into important demographic traits, perspectives, and worries concerned to the maritime sector. The bulk of the participants were men, ranging in age from 18 to 34. They had a minimum of a high school diploma and between 6 and 10 years of professional experience. The most numerous occupations were held by fishermen, who mostly held executive and managerial roles.

A high degree of worry was found when analysing the respondents' knowledge of weather change concerns and their views on the danger that weather change poses to the maritime sector. The necessity for immediate action was highlighted by the fact that most

respondents were aware of weather variation and saw it as a main danger to the maritime sector. Statistical tools, instances of statistical techniques include regression analysis and correlation testing, were used to thoroughly examine the study's hypotheses.

The theories were supported by the outcomes, which look that the marine industry is significantly exaggerated by weather change, coastal erosion and accretion are affected by rising sea levels, agricultural production is affected by climate change, and maritime transportation is affected by interruptions in oil transportation. Eventually, the study emphasizes the critical significance of promptly tackling the complex issues that the maritime industry faces as a result of climate change. This report is great for scholars, politicians, and industry stakeholders since it lays out the complex interplay between environmental change and the maritime sector in detail. Protecting coastal populations, marine ecosystems, and maritime industries from the dangers caused by climate change requires effective adaptation and mitigation techniques

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER I:

INTRODUCTION

1.1 Overview

One cannot deny the reality of global warming. Earth's climate has been steadily increasing temperature during the course of the last century, notably during the past two to three decades. Ecosystems in the region's coastline are more susceptible to the impacts of environment change due to of their location and the high intensity of human activity there (Wang et al., 2012). As a result of climate change, marine, and coastal environments are under cumulative threat from a variability of threats, comprising rise in levels of sea along with surface temperatures, acidification of the oceans, adverse weather conditions, etc. It is a serious obstacle to the expansion of the maritime industry in the long run.

Maritime Industry plays a crucial role in global commerce and serves as the foundation for the global economy. Without maritime industry the world's current level of prosperity and the development of nations would not have been achieved & might not be involved in trading. Around 90% of world trade is carried through international shipping industry and the growth of maritime commerce persists, providing advantages for global customers by offering competitive transportation expenses. Due to the increasing efficacy of shipping as a means of transportation (Wagner, 2021).

Marine businesses utilize laptops and cyber-dependent technology for many functions including navigating, interaction, tracking and overseeing vessel networks, transferring cargo, managing availability, inspecting passengers and cargo, detecting fires, conducting finance and other commercial operations, and fulfilling other objectives.

Increased intensity and frequency of storms, including both tropical and winter storms, are causing severe disruptions to conventional marine commerce routes. Vessels is common

for ships to have to change their intended courses in order to reduce or avoid the negative effects of severe weather, which might lead to cancellations or increased fuel usage. Vessels that do not use an atmospheric navigation system may encounter substantial delays or, in the most severe situations, suffer cargo loss or damage (Wagner, 2021).

Ports are also affected by the rising occurrence of hurricanes, which may potentially cause harm to infrastructures during the most severe hurricanes. At the very least, these technologies will cause greater numbers of interruptions to be trucking and unloading activities, leading to inconveniences for owners, charter companies, and consumers. In the future, ports will be affected by the gradual increase in sea levels, which may need substantial modifications of the infrastructure. Such might have severe consequences for the towns located along the shore (Wagner, 2021).

The weather and natural catastrophes can be somewhat unforeseeable, but the ability to forecast the onset and impact of these events has grown harder because of global warming. The above poses a significant challenge in managing supply chains on numerous fronts. Climate change is largely driven by a sharp rise of atmospheric greenhouse gases in the environment of the planet, mainly thanks to the consuming of petroleum and coal (Austin Becker, 2018).

Climate change has the potential to disrupt distribution networks via events such as unexpected tsunamis, rapid blazes, and the movement of workers or a requirement to modify facilities. Such scenarios, as well as other factors such as interruptions to transportation, input suppliers, and consumers, will have either an immediate or secondary effect on a company's financial performance (Sahya et al., 2021).

Logistics workers possess firsthand knowledge of the ongoing degradation, including the impact of influenced maritime routes, changes in weather conditions, unexpected hurricanes, and ecological transformations. These factors significantly influence their

operations, leading to the need for changes, alterations, or even abandonment of developed company practices and routes of trade (Austin Becker, 2018).

Vessels mostly release carbon dioxide (CO2), which is a significant greenhouse gas (also known as GHG) with a potential to cause warming of ninety- eight percent. In accordance to a study conducted by the International Maritime Organization (IMO), the regulatory body tasked with protecting the ecosystem and the management of the marine environment, the shipping sector was found to account for around three per cent of the total world carbon dioxide (CO2) emissions in the year 2007. Annually, which is equal to one thousand fifty million metric tons of CO2, with shipping worldwide responsible for two and half percent out of the total. These emissions are comparable to those of an industrialized country. One effective method of decreasing CO2 emissions is to limit the pace of cruising, sometimes known as gentle steamed. This approach cuts emissions at ocean in the near future, however, it is expected to lead to a rise in CO2 emissions on ground in future years (Buhangetal, 2009).

Climate change could have significant repercussions on commerce, particularly through the increased occurrence of severe storms and higher seas. The physical structure for availability, transportation, and shipment strands are projected to grow more susceptible to problems as a result of changes in the climate. The impact of warming temperatures on maritime transport facilities and supply chains is expected to be multifaceted, including both advantageous and detrimental effects (Patrick Schmitt, 2020).

Because of this, it will be extremely useful to conduct a comprehensive study of how climate change is impacting various marine industries. The study aims to offer evidence needed for the formulation of plans and laws that effectively address climate change while simultaneously fostering the growth of the marine sector. Despite the widespread properties of weather variation on the maritime economy, only a fraction of climate change studies has

addressed these effects in any detail. To yet, studies have primarily looked at certain marine businesses that are vulnerable to changes in the climate, including marine fisheries along with coastal tourism (Kong et al., 2018).

1.1.1 Climate Change

As per the "Intergovernmental Panel on Climate Change (IPCC)", changes in climate are "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its characteristics and that persists for an extended period, typically decades or longer" (Shyam and Manjusha, 2015). Internal processes, external forcings, and long-lasting anthropogenetic changes to the atmospheric or usage of land composition are all potential causes of climate change. Rising worldwide means atmospheric temperatures in the oceans, widespread ice and snow melting, and an upward trend in average worldwide water levels are all indicators of an increasingly hot climate system. Here has been a rise of 0.76 degrees Celsius in global mean seeming heat since 1850. Human activities are likely responsible for the great majority of the increase in temperature that took place in the last fifty years.

In its "fourth assessment report", the "Intergovernmental Panel on Climate Change" (IPCC) projects that global average surface temperatures will upsurge by an additional one to a half and four deg., the temperature has increased by up to six and half percent Fahrenheit in the current period in the event of a catastrophic climate change if no further action is taken to reduce emissions of greenhouse gases. Even at the most modest portion of the above spectrum, the total degree Celsius rise during the beginning of industrialization will still exceed two degrees Celsius, the point at which the likelihood of irrevocable and perhaps disastrous consequences significantly rises. Several vulnerability assessment methods and adjustment approaches are proposed to split with the consequences of weather change on marine environments, fish, and fisheries, all of which are now being felt (Shyam and Manjusha, 2015).

Climate change means enduring alterations in heat and conditions over an extended period of time. These alterations may occur naturally as a result of variations in solar radiation or significant lava flows. However, starting from the nineteenth century, human actions have been identified as the primary catalyst for global warming, mostly as a result of the combustion of energy sources such as oil, gas, and coal. The combustion of carbon-based fuels produces GHGs emissions that function as a thermal insulator enveloping the planet, capturing sunlight's warmth and elevating heat. Methane and carbon dioxide are the primary GHGs that are responsible for global warming. These emissions result from the use of fuel for operating a vehicle or charcoal for warming a structure, as exemplified. Deforestation and land clearance may also result in the emission of carbon dioxide. The agricultural sector, gas and oil industries are significant contributors to emissions of methane. The primary industries responsible for GHGs emissions are power, business, transportation, structures, farming, and the utilization of land (Shyam and Manjusha, 2015).

1.1.2 Climate Change and Marine Ecosystem

Maritime ecosystems are dynamic systems that respond to environmental changes on a wide range of geographical and temporal dimensions. Temperature shifts are associated with changes in marine circulation patterns, which in turn are impacted by shifts in the trajectory and strength of the winds which influence currents through the ocean and combine surface water with water that is rich in nutrients found deeper in the ground (Kennedy et al., 2002). Plankton, an important food source for smaller fish, are impacted by these processes in turn. Figuring out ways to manage through the outcomes of the changing weather on coastal communities may be one of the most serious challenges during this time as well as the next several millennia. Climate change may impact nearshore marine ecology because extreme and unpredictable natural forces have a greater impact on coastlines.

The oceans will warm by a few degrees Celsius for every degree that the air warms and this will impact many different areas on the hydrologic cycle and both the chemical and physical composition of water. These factors will cause Changes in the dispersion of aquatic microbes and estuarine communities' fish, invertebrates, and species of vegetation (McGinn, 2002). Fishes have functional adaptations that permit them to thrive only in a narrow array of environmental circumstances; living beyond this range can be extremely challenging, if not lethal (Barton et al., 2002). For fishes that have adapted to the same environments, their distributions may overlap (Attrill, 2002). Inputs from a variety of primary manufacturing sources as well as detrital food webs make estuarine and coastal habitats exceptionally productive. However, these systems offer the biota a challenging setting, one that requires the evolution of physiological or psychological adaptations for organisms to survive the large variety of physical and chemical factors present (Horn et al., 1999). Migration patterns are influenced by several factors, including temperature. This is because migratory animals actively seek out habitats that include their preferred range of ecological variables (Soto, 2002; Murawski, 1993; Rose and Leggett, 1988).

Major climate phenomena like "El Niño/La Niña Southern Oscillation (ENSO)" are predictable to grow in regularity and intensity in the forthcoming (IPCC, 2001; Timmermann' et. al., 1999), might have severe consequences for fish populations, specifically if added to additional stresses like overfishing (Pauly and Christensen, 1995). The impacts of intense harvesting may be exacerbated by ENSO occurrences, which have been linked to lower survival rates, slower growth rates, and changes in migration patterns (Miller and Fluharty, 1992). Oceanographic and environmental conditions throughout the Pacific Ocean's waters undergo dramatic shifts due to the El Nino phenomena, with effects felt as far inland as the "Peruvian coast (Zuta et. al., 1976)"; this has had a significant impact on pelagic resources,

leading to shifts regarding their biological functioning, changes in behaviour, and a slow but steady decline in population (Valdivia, 1976).

1.1.3 Climate Change and Fishers

Communities of fishermen in general have strong attachments to their physical surroundings since the water is so central to their way of life. The possessions of weather change on those who rely on maritime resources include, among other things, uprooted families, problems with food security, the migration of fishermen, a decrease in income, seasonal work, a shift in work schedules, higher fishing costs, fewer fishing days, and other factors (Shyam and Manjusha, 2015).

a) **Demography and Social standards:** Food insecurity has become a major problem since the figure of displaced persons and the proportion of young populations who aren't interested in fishing have risen sharply in recent years. Since profits from marine fishing have not stifled speed with the development in the number of fishermen, hidden joblessness is rife across all industries. As a result, people are leaving their local areas in search of work because of the high wages and limited assets in the faraway seas.

b) **Infrastructure sensitivity:** As well as posing a threat to coastal populations from erosion, flooding, as well as storm damage, sea conditions have become unsuitable for fishing as a result of the amplified regularity and strictness of dangerous climate occurrences. The homes of the fishers are placed in a region with a superior threat of natural disasters, and their property losses have steadily risen over time.

c) **Income Effect:** Fishermen's revenue has fallen dramatically over the years. There is economic loss owing to a reduction in fishing days, and the employment pattern is primarily seasonal, leaving few alternatives for people looking for work. Fishing and storing costs

rose as fishermen had to relocate to more expensive areas. There has been a steady increase in the price of fuel, fishing equipment, and boats (Shyam and Manjusha, 2015).

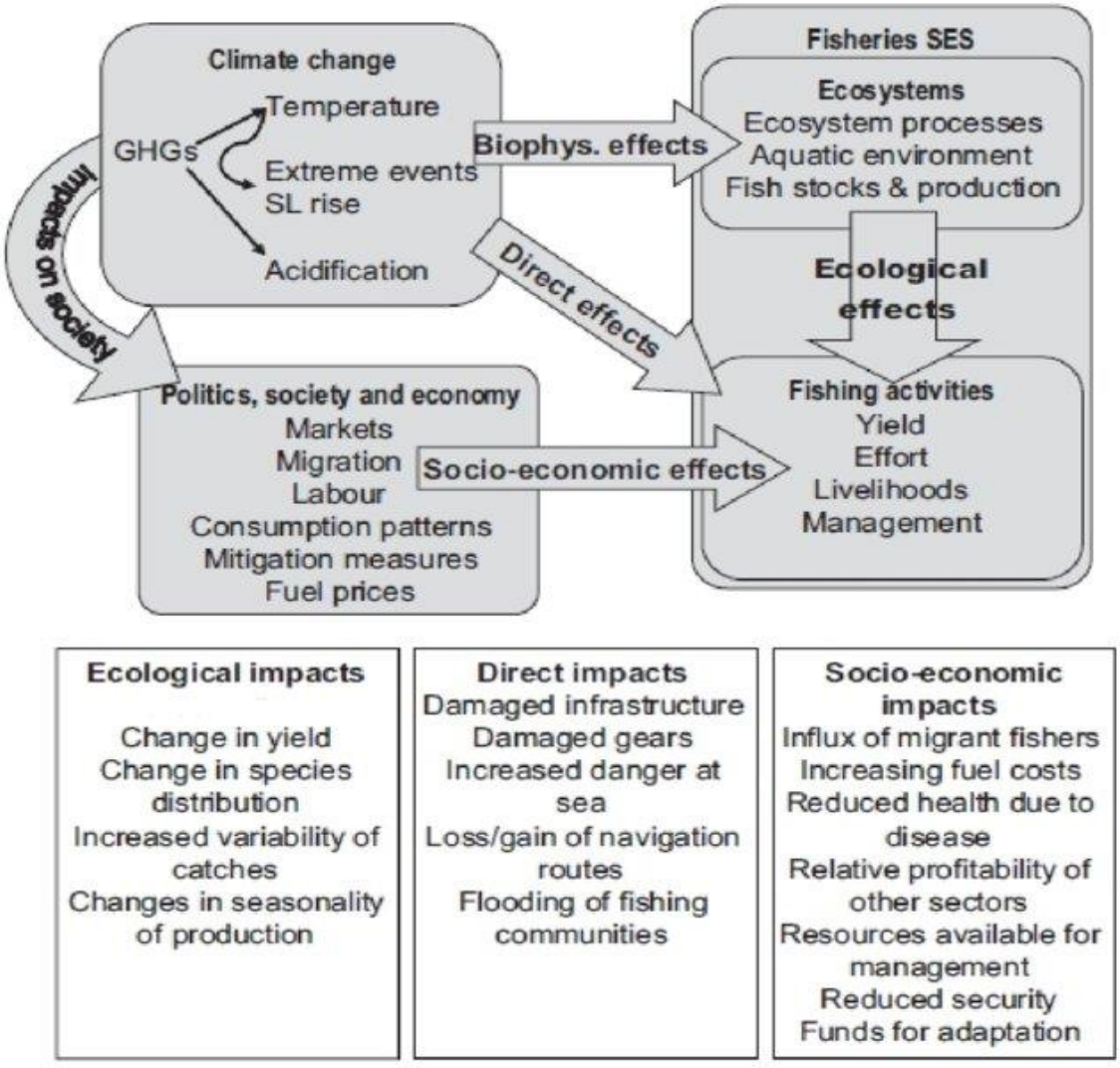


Figure 1: "Ecological, direct and socioeconomic impacts of climate change on fisheries"

(Source: Kim, 2022)

1.1.4 Impact of Climate Change on Marine Transportation Industries

Loss due to climatic catastrophes and the adverse outcomes of emission reduction rules on the shipping sector are two key ways in which the changing climate is having a detrimental effect on maritime transportation. The approximate height of the port terminals along with

warehouses will fall as a outcome of ocean level increase, increasing the likelihood of storm surge flooding and reducing the efficiency of the port as a whole (Science Press, 1994); interruption of harbour and shipping operations, building damage, and personal injuries to workers are all possible results of extreme weather (Rongshuo and Qinghua, 2014). On top of that, the environmentally friendly shipping model is advocated for carbon reduction in the context of weather alteration has a greater result on the naval commerce: upgrades to ships, electricity, routes, and management systems are needed (Liu Xiancheng, 2012).

Offshore petroleum and natural gas platforms are especially at danger from environment shift as they are directly involved in the extraction and usage of marine resources (Rongshuo and Qinghua, 2014). However, taking measures to reduce "greenhouse gas (GHGs)" emissions are expected to encourage the expansion of the marine power industry (Zhao Shiming, et. al., 2008; Allan, 2014), the growth of the ocean energy sector, which aims to accomplish carbon reduction targets through increasing the contributions of ocean power to national energy structures, will, on the other hand, be facilitated by initiatives to mitigate climate change (Kong et. al., 2018).

1.1.5 Identification of the key impacts of climate change on marine economy

Rising sea levels, increasing ocean temperatures, acidification of saltwater, more extreme weather, and efforts to curb emissions all contribute to the devastation wrought by global warming. Analysis of the previously mentioned research on the suggestions of weather alteration on the marine area's economy and in-depth interviews with industry experts inform this part, which illustrates the influence of the main factors having an impact on the marine sector (Table 1). This study analysed the effects on 12 major marine industries based on data from the "Statistical Bulletin of China's Marine Economy", which are as follows: seawater utilities, ocean construction, ocean power, marine shipbuilding, maritime piscaries, seaward crude oil and natural gas extraction, maritime salt production, maritime biology and

oceanography, shipping, maritime chemistry, coastal mining, and medical, offshore oil along with gas extraction, ocean engineering, ocean construction, and marine shipbuilding.

"Table 1: Key Impacts of Climate Change and Emission Reduction Policies on Marine Industries"

	"Sea-level rise"	**"Sea surface temperature rise"**	**"Seawater acidification"**	**"Extreme weather"**	**"Emission reduction policy"**
"Marine fishery"	"Inundation of beach culture areas; Inundation of factory buildings which affects aquatic product processing"	"Change the habitat environment, and reduce fish population; Change the spatial distribution of fishery resources"	"Influence the life history of fish, change the habitat environment, reduce fish population, and affect marine fishing"	"Damage aquaculture facilities; Affect the normal development of outdoor farming and fishing activities"	"Energy conservation and emission reduction affect marine fishing"
"Marine oil and gas industry"	"Increase the difficulty and cost of mining"			"Affect exploration, transportation and	"Change the energy structure and reduce the

				other production activities”	need for fossil fuels”
“Ocean mining”	“Increase the difficulty and cost of mining”			“Affect coastal ore and other mining activities”	“Change the energy structure and reduce the demand for coal”
“Ocean salt industry”	“Inundation of existing salt pan; Inundation of the factory buildings and affect salt processing”			“Storm surge damages salt fields; Affect outdoor salt mining activities”	“Change the existing production mode”
“Marine chemical industry”	“Inundation of the factory and affect normal production activities”			“Reduce number of days for normal production activity. However, the impact on indoor production is relatively low”	“Change the existing production mode”

“Marine biomedicine”	“Inundation of the factory and affect normal production activities”			“Reduce number of days for normal production activity. However, the impact on indoor production is relatively low”	“Change the existing production mode”
“Marine power industry”	“Increase the construction cost; Some wind turbines would be flooded and additional protection is needed”			“Storm surge increases the number of off days for the turbines; Storm surge increases the construction cost of tidal and wave power station”	“Change the energy structure and increase the demand for clean energy such as offshore wind energy and ocean energy”

“Seawater utilization industry”	“Inundation of the factory and affect normal production activities”			“Reduce number of days for normal production activity. However, the impact on indoor production is relatively low”	“Change the existing production mode”
“Marine ship building industry”	“Inundation of docks and factories; Heightening of the port would increase production costs”			“Affect outdoor ship repair and dismantling; Increase cost for protection against storm surges”	“Change the existing production mode”
“Marine engineering construction”	“The demand for construction of protective infrastructures rise; Increase construction costs; Inundation of			“Promote the development of marine engineering construction; Reduce the number of days	“Change the existing production mode”

	existing production facilities”			for normal outdoor construction work”	
“Marine transportation industry”	“Inundation of port terminals affect normal production activities; Increase production costs”			“The storm surge affects the number of days for normal sea transportation; Affect outdoor activities; Increase cost for protection against storm surges”	“Low-carbon shipping mode”
“Coastal tourism”	“Inundation of coastal tourism resources, including cultural relics and natural landscapes such as wetlands; Inundation of	“Loss of natural landscape of the sea; Change the spatial distribution of tourism resources”	“The marine ecosystem would be damaged and the natural landscape would be lost”	“Destroy the cultural relics of the coastal zone and natural landscapes such as wetlands; Reduce Ocean	“Change the existing production mode”

	coastal holiday accommodation”			sightseeing and other outdoor leisure activities”	

Table 1: Key Impacts of Climate Change and Emission Reduction Policies on Marine Industries (Source: E3S Web of Conferences 53, 2018)

https://doi.org/10.1051/e3sconf/20185303072 ICAEER 2018

1.1.6 Impact of Climate Change on Marine Industries

The maritime business as a total—which includes shipping, fishing, aquaculture, and coastal tourism—faces a growing number of serious threats from climate change. In this part, the study will examine many significant ways in which the changing climate is already affecting the maritime sector:

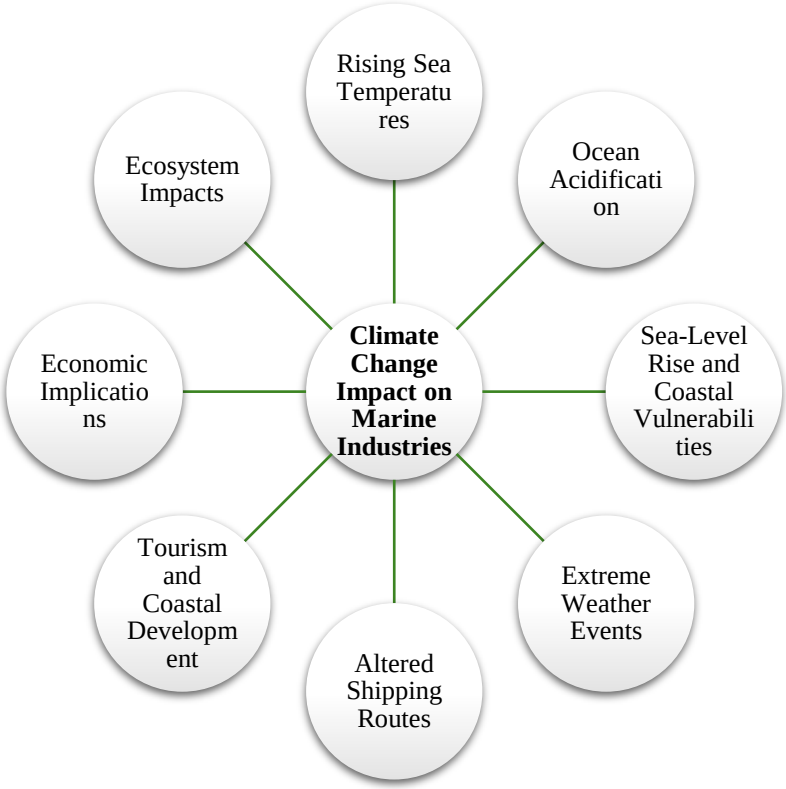


Figure 2: Climate Change Impact on Marine Industries

a) **Rising Sea Temperatures:** The expanding water heat of the sea is one of the greatest noticeable results of global warming's impact on the marine ecosystem. Impacts of this increase include population shifts in fish, changed mating seasons, and new distribution patterns for marine organisms (IPCC, 2019). As a result of these shifts, fisheries are becoming less productive and lucrative.

b) **Ocean Acidification:** As a result of absorbing an excessive amount of carbon dioxide (CO2) from the atmosphere, the seas get acidified. Corals and some types of plankton, which have skeletons made of calcium carbonate, are particularly vulnerable to this (Doney et al., 2012). As a result of increasing acidity, the aquaculture business, which is dependent on shellfish as well as mollusks, is in jeopardy.

c) **Sea-Level Increase and Coastal Vulnerabilities:** The seaside infrastructure, such as ports and coastal villages, is in danger due to the emerging ocean razes initiated by

environment change. Damage to port infrastructure, flooding of low-lying communities, and worsened coastal erosion are all possible results of sea level rise (Nicholls et al., 2011). The economic viability of shipping and tourism along the coast is directly threatened by these changes.

d) **Dangerous Weather Events:** Dangerous weather phenomena, such as powerful cyclones and cyclones, are becoming more and more powerful as a result of climate change. Disruption of shipping operations, vessel damage, and maritime safety risks are all possible outcomes of such occurrences (Emanuel, 2013).

e) **Altered Shipping Routes:** Arctic Ice Melting New routes for shipping, including the Northern Shipping Route along with the Northwest Passage, have been made possible owing to the melt of ice began by global heating. Shorter travel durations are a potential benefit, but there are also risks to navigation, growth of infrastructure, and environmental preservation (Stephenson et al., 2013).

f) **Tourism and Coastal Development:** The consequences of environment alteration, such as increasing ocean levels, beach erosion, and more intense storms, pose serious threats to the coastal tourist industry (Becken et al., 2013). In addition, resorts and hotels located along the shore are vulnerable to destruction caused by natural disasters (Mandegarian et al., 2020).

g) **Economic Implications:** There will be major monetary repercussions for the maritime sector as a result of climate change. For instance, fisheries are vital to the world's economy and food supply because they provide jobs for more than 56 million people (FAO, 2020). When fisheries are impacted by climate change, it can have a domino effect on the food supply and the economy.

h) **Ecosystem Impacts:** Highly exposed to the impacts of global warming are aquatic environments, which can alter species richness and distribution. Because of the interconnectedness of the food system, the ecological effects of these shifts can be profound (Cheung et al., 2013).

In conclusion, the maritime sector faces a complex challenge from climate change, with wide-ranging financial, environmental, and societal repercussions. Industry stakeholders, politicians, and researchers must work together to create innovative approaches and environmentally friendly procedures to protect the maritime industry's future in the surface of weather alteration as the implications become clearer.

1.1.7 "Climate Change Impacts on Coastal and Marine Environments"

There is mounting demonstrate from scientific studies that the planet's weather is shifting, and it's virtually likely that human actions are a major contributor to the rate and magnitude of these shifts. An enormous agreement of study on the subject of altering climates has shown that coastal areas are particularly susceptible to its consequences. The "Intergovernmental Panel on Climate Change (IPCC)" is the leading organization in the study of climate change and its effects, adaptations, and prevention strategies. The "4th Assessment Report (AR4)" issued by the IPCC in 2007 indicates with high confidence that coastal areas would be more uncovered to weather modify threats such as seaside subsidence and marine-level improvement (IPCC, 2007b). This study provides a thorough compilation of the current information, including recent observations of climate-related changes and forecasts of future implications across a wide range of both human and natural habitats. Although the consequences for the tourist industry are not often clearly addressed, the AR4 includes a plethora of content that is pertinent to the industry (Amelung et al., 2008).

Losses of wetland ecosystems and the mangroves and growing harm from floods (actual high assurance), corrosion of coasts decreasing the charge of these locations for travel (extreme

self-confidence), and harm to infrastructures clearances, and conveniences that contribute to employment in tiny settlements (actual great self-confidence) are just some of the impacts detailed in “the IPCC report (IPCC, 2007b) that are relevant for the tourism industry.” Major changes in environments and species, as well as larger-scale coral bleaching events, are predicted to occur as a result of increasing average heats, while fluctuations in the cycle of water are highly likely to upsurge the number and harshness of regions impacted by deficiency and overflows (high confidence). According to the data, coastal and marine tourist industries are particularly vulnerable since they trust on resources that are susceptible to weather transformation. Low coastal locations are often where these types of businesses are located (Moreno and Amelung, 2009).

1.1.8 Climate Change and Coastal & Marine Tourism

A reciprocal link exists between warming temperatures and tourism (Patterson, et al., 2006). Both **(i)** the availability of environmental, social resources, and physical for vacation industry, and **(ii)** the ease, satisfaction, and sense of security experienced by those involved are directly influenced by the weather. However, “greenhouse gases (GHG)” emitted from hotels, attractions, and most of all, vehicles, are a major reason why tourism is contributing to anthropogenic worldwide climate change. The consequences of this connection are the topic of this section (Moreno and Amelung, 2009).

The worldwide community continues to prioritize initiatives to reduce emissions of carbon and enhance the ecological effects of global transportation. The "International Maritime Organization's" decision in the fourth month of 2018 to implement a plan aimed at achieving a minimum of a fifty percent decrease in yearly GHGs emissions from vessels by the year 2050, relative to 2008 levels, is a very significant event. Starting in January 2020, a worldwide restriction of half on the amount of sulfur in petroleum products will be implemented to address environmental concerns. In order to maintain uniform enforcement of the worldwide limit on

sulfate that is crucial for the maritime industry to persistently evaluate and embrace different approaches, such as adding cleaners and transitioning to LNG along with other fuels that have minimal sulphur content (transport, 2018).

- **Implications of Climate Change on Coastal & Marine Tourism**

Weather and weather alteration disturb coastal and maritime activities in different habits and to different degrees. However, while the connection is clear for some activities (such as sunbathing, which necessitates a certain temperature, and clear skies, along with no precipitation), it is less so for others (such as the climate necessities for environment viewing or the effects of weather alteration on creature inhabitants). This is one reason wherefore scientists are just beginning to appreciate the advantages and disadvantages that weather alteration may present for specific types of tourism. Because of this, there is a severe lack of assortment in the current works on the subject of the changing climate and tourism, with the massive mainstream of lessons focusing on the aspects of the industry that are most susceptible to the vagaries of the elements (Moreno and Amelung, 2009).

1.1.9 The Global Summits and Policies

The worldwide community has conducted conferences or summits once a year to evaluate progress in combating climate change, and this has established a basic roadmap towards climate action. These conferences were pivotal because they resulted in the discussion and design of global climate change policy, which will be implemented in the coming years. The worldwide community's engagement with climate change has prompted the gatherings listed in Table 2 (Shyam et. al., 2017).

Table 2: List of significant international climate change policy events

"Date"	"Event"	"Description/Outcome"

“Nov. 1988”	“IPCC Established”	“World Meteorological Organization WMO and UN Environment Programme UNEP establish the Intergovernmental Panel on Climate Change IPCC”
“Nov. 1990”	“IPCC and Second World Climate Conference Call for Global Treaty”	“The IPCC releases the first assessment report saying “emissions resulting from human activities are substantially increasing the atmospheric concentrations of greenhouse gases” leading to calls by the IPCC and the second World Climate Conference for a global treaty”
“Dec. 1990”		“UN General Assembly Negotiations on a Framework Convention Begin”
“Jan. 1992”		“UNFCCC Opens for Signature at Rio Earth Summit”
“March 1994”	“UNFCCC Enters into Force”	“Parties meet annually at the Conference of the Parties (COP) to negotiate multilateral responses to climate change”
“April 1995”	“COP 1”	“The Berlin Mandate establishes a process to negotiate strengthened commitments for developed countries, thus laying the groundwork for the Kyoto Protocol”
“Dec. 1997”	“COP 3”	“Adoption of the Kyoto Protocol, the world’s first greenhouse gas emissions reduction treaty”
“Nov. 2001”	“COP 7”	“Formalize agreement on operational rules for International Emissions Trading, the Clean Development Mechanism and Joint Implementation”
“Feb. 2005”		“Kyoto Protocol enters force”

“Jan. 2006”		“Clean Development Mechanism Opens”
“Nov. 2006”	“COP 12”	“Programme to address impacts, vulnerability and adaptation to climate change”
“Jan. 2008”		“Joint Implementation Mechanism Starts”
“Dec. 2010”	“COP 16”	“The Green Climate Fund, the Technology Mechanism and the Cancun Adaptation Framework are established”
“Dec. 2011”	“COP 17”	“Governments commit to a new universal climate change agreement by 2015 for the period beyond 2020”
“Dec. 2012”	“COP 18”	“Launch of a second commitment period of the Kyoto Protocol”
“Dec. 2013”	“COP 19”	“A rulebook for reducing emissions from deforestation and forest degradation and a mechanism to address loss and damage caused by long-term climate change impacts”
“Dec. 2015”	“COP 21”	“An historic agreement to combat climate change and unleash actions and investment towards a low carbon, resilient and sustainable future was agreed by 195 nations at the 21st Conference of the Parties of the UNFCCC in Paris and adopted by consensus on 12 December 2015”

Table 2: List of significant international climate change policy events (Source: Shyam, S. S., Shridhar, N., & Fernandez, R, 2017)

- **Coalition Core Strategy for Climate Change Policy**

There has to be a careful balancing of the primary roles that different agents of climate change play while the policy is being drafted. The governing body, local leaders, large-scale emitters like companies, and the people (both as victims and as potential perpetrators) are all key characters in the climate change drama. As shown in Figure 3, the coalition approach for mitigating climate change includes a delicate balancing act between national and local agencies. The federal government ought to initiate measures to improve infrastructure like promoting solar houses, solar on schools, better-performing transmission lines, etc., and seek out the biggest contributors to decrease carbons by giving for reductions, striking an effective balance between “Top-Down (TD)” and “Bottom-Up (BU)” strategy. In return, businesses are liable for the cost of carbon emissions that are higher than regulatory limits (Shyam et al., 2017).

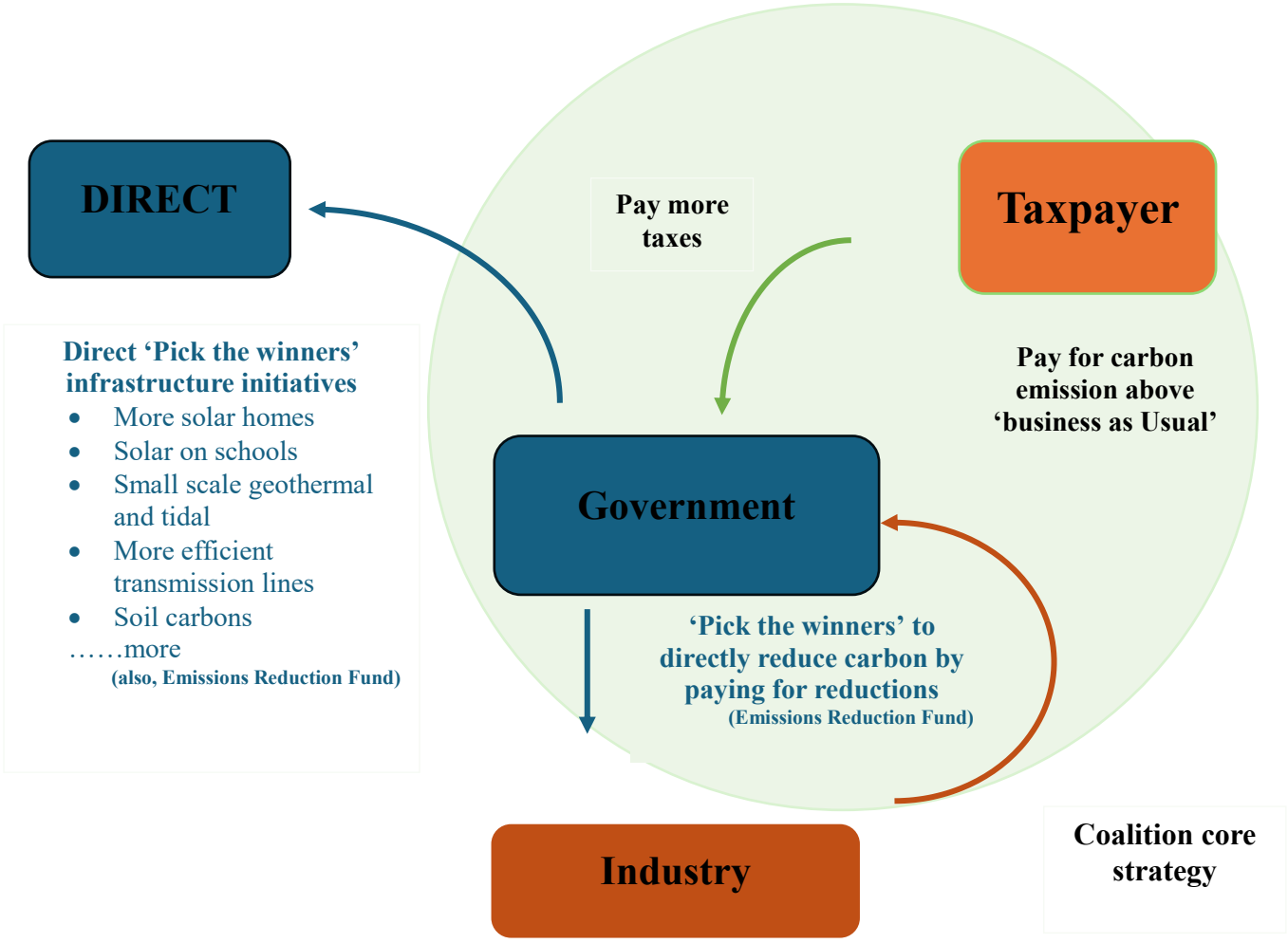


Figure 3: Coalition strategy for climate change policy (Source: Shyam et al., 2017).

- **Impact Study**

The extent of these effects, and whether they are positive or negative, will change on factors like position, genus, and the overall health of the stock. The consequences of weather change on aquaculture will be felt on a local, state, and federal scale. It is anticipated that weather change will affect fishing practices, species composition, and overall harvest quantities. Fishing villages and industries will feel the consequences of this shift. There may be more far-reaching negative implications on the national level, involving effects on exports, creation of employment, development of the economy, and "Gross Domestic Product

(GDP)" If numbers of fish decrease as a result of excessive use of natural assets and the effects of warming temperatures (Shyam et al., 2017).

Table 3: Types of changes and their impacts

"Type of changes"	**"Climatic variable"**	**"Impacts"**	**"Potential outcomes for fisheries"**
"Physical" "environment"	"Ocean acidification"	"Negative effects on calciferous animals, including slowed rates of coral growth"	"Declines in production"
	"Warming of upper" "Ocean layers"	"Poleward shifts in plankton and fished species"	"Changes in production and availability of fished species"
		"Changes in timing of phytoplankton blooms, Changing zooplankton composition"	"Potential mismatch between prey (plankton) and predator (fished species) and declines in production"
	"Sea level rise"	"Loss of coastal habitats. Saline intrusion into freshwater habitats"	"Reduced production of coastal marine and freshwater systems and related fisheries"
"Fish stocks"	"Higher water temperatures"	"Changes in physiology and sex ratios of fished species, Altered timing of spawning, migrations, and/or peak abundance"	"Changes in timing and levels of productivity across marine and freshwater systems"

		“Increased invasive species, diseases and algal blooms”	“Reduced production of target species in marine and fresh water systems”
	“Changes in ocean currents”	“Effects on fish recruitment”	“Changes in abundance of juvenile fish and therefore production in marine and fresh water”
“Ecosystems”	“Reduced water flows & increased droughts”	“Changes in lake water levels, Changes in dry water flows in rivers”	“Reduced lake productivity, Reduced River productivity”
	“Increased frequency of ENSO events”	“Changes in timing and latitude of upwelling”	“Changes in pelagic fisheries distribution”
	“Higher water temperatures”	“Increased frequency and severity of coral bleaching events”	“Reduced coral reef fisheries productivity”
		“Changes in stratification, mixing, and nutrients in lakes and marine upwellings”	“Changes in productivity”
“Coastal infrastructure and fishing operations”	“Sea level rise”	“Coastal profile changes, loss of harbours and homes, Increased exposure of coastal areas to storm damage”	“Costs of adaptation make fishing less profitable, increased costs of insurance and/or rebuilding, and

			increased vulnerability of coastal households.”
	“Increased frequency of storms”	“Fewer days at sea, increased risk of accidents, Aquaculture installations (coastal ponds, sea cages) at greater risk of damage”	“Reduced viability of fishing and fish-farming as livelihood options for the poor; reduced profitability of larger-scale enterprises, increased costs of insurance.”
“Inland fishing Operations and livelihoods”	“Changing levels of precipitation”	“Where rainfall decreases, reduced opportunities for farming, fishing and aquaculture as part of rural livelihood systems”	“Reduced diversity of rural livelihoods; increased risks in agriculture; greater reliance on non-farm income”
	“More droughts or floods”	“Damage to productive assets (fish ponds, weirs, rice fields, etc.) and homes”	“Increased vulnerability of riparian and floodplain households and communities”
	“Less predictable wet/dry seasons”	“Decreased ability to plan seasonal livelihood activities”	

Table 3: Types of changes and their impacts (Source: Shyam, S. S., Shridhar, N., & Fernandez, R, 2017)

1.10 The Marine Species under Climate Change

The temperature and acidity of their environments are crucial to the health of the creatures that call those places home. Sea levels rising, carbon dioxide in the atmosphere rising, the world getting warmer, and the Arctic ice cap getting smaller are all signs of climate change. The basic functions of any living thing are survival and reproduction. Thus, the bioclimatic envelope becomes crucial as a measure of the time a given individual must pass before accessing a reproductive environment. The relative size of the envelope determines the significance of all other phenological characteristics. Variety with restrict bioclimatic varieties are more vulnerable to elimination and environmental change than those with wider ranges. The breadth of a species' ecological envelope is a key measure of its susceptibility to environmental and ecological changes (Wang, 2022).

The struggle for survival and procreation is fraught with mismatch as well. The phenology of a population "drifts out" from the movable envelope if the degree of climatic alteration is quicker than the degree of adaptations, and "jumps out" if the variability of the envelope is greater than the population's ability to control phenology variation. There are a lot of moving parts that affect how much room there is for drifting and leaping out. The migratory signal, which triggers phenotypic plasticity, must coincide with the bioclimatic envelope. when opposed to populations that rely on weather-driven factors like temperature, those that rely on timing cues like photoperiod are unlikely to adjust via phenotypic plasticity when the environment changes. Ocean temperatures are fast increasing in tandem with global warming. Due to the temperature rise, marine animals will have to relocate their habitats, depending on the size of their thermal envelope. As a result of a rise in the mean temperature of the ocean's surface, fish that require a cooler environment to survive will have to go deeper into the ocean in search of it. More and more marine organisms are moving to shallower waters, meaning that the initial species that have always called the deep ocean home may soon be forced to relocate.

Under those conditions, all life on Earth would perish. A total collapse of the marine environment would result from an extinction event, as these extinctions occur inside ecosystems (Wang, 2022).

1.10.1 Fishing Industry under Climate Change

Climate change poses a hazard to worldwide food security that is both present and future. One of the most rapidly expanding food industries worldwide, aquaculture (also known as aquatic farming) is still largely unexplored by scientists. If the existing unequal distribution of production patterns persists, a reduction in seafood yields might have a direct effect on world economies and food security. Since about 90% of all marine cultivated biomass is presently generated in Asian countries, it is possible that bivalves and finfish might not develop as grow as they formerly ensured. In certain cases, choosy animals can make up for a drop in enlargement performing, but this isn't always the case. Species that are pushing up against their ability to tolerate limits, trade-offs among growth and tolerance execution, a plethora of stressors, and barriers to information transmission can all make this process more (Anderson et. al., 2013).

Through commerce, countries with safer or less-affected regions might boost global economic security and growth. The change in production capacity for some places, based on farming sites, at the national level may be mitigated by the fluctuation of the seas in the nation's EEZ, especially for nations with extensive marine resources. Despite a general decline in production potential, future gains in biomass may be achieved via the adoption of appropriate breeds and/or farm siting if just a tiny fraction of the world's productive waterways are needed to meet the world's need for seafood. Humans will find fewer fish suitable for consumption as marine species decline and go extinct. Since edible fish is a major food supply for island nations, a decline in their population might have devastating effects (Anderson et. al., 2013).

1.10.2 Coral Reef under Climate Change

In terms of biodiversity and economic value, coral reefs rank among the highest. Numerous species, including 4,000 types of fish, 800 kinds of stony coral, and hundreds more, may thrive there. Over twenty percent of all the maritime fish species live in coral reefs. It's because the reefs provide a secure environment for them to eat, breed, and bring up their young. Devastating damage to coral reefs may have far-reaching consequences for the local community, causing inhabitants to lose a sizeable percentage of their economic earnings and lowering the existence of aquatic life that relies on the reefs for survival. Temperatures below 23 degrees Celsius are too warm for corals, and most corals can survive in circumstances around 23 and 29° Celsius. Because of this, coral reefs can only exist in specific locations. However, some corals have a short-term tolerance of temperatures as high as 40 degrees Celsius. Consequently, most corals are found in seas that are subtropical or tropical, across the "tropics of Cancer and Capricorn". This means that the current speed of weather change may be very quick for coral reefs to adjust and recover. Scientists have observed, however, that coral reefs in certain areas, notably in the Pacific's more remote regions where reefs remain far distant from human effects, have shown resilience in the face of rising water temperatures and bleaching (Anderson et al., 2013).

1.10.3 Seagrass under Climate Change

Seagrass meadows and algal forests are two of the greatest prolific and varied coastal aquatic ecologies in the earth. Fish and invertebrates rely on these ecosystems as nurseries and food sources. They also provide erosion control, retention of carbon, and nutrient fixation. The warming of the oceans is the most significant worry among global change in climate factors because it is the most important limiting factor for the range of marine macrophytes. It is predicted and widely established that as a consequence of global warming, dominant macrophytes would disappear from their equatorial range constraints and expand into the polar regions. Several non-genetic mechanisms, including the functional composition of the

connected microbiome and epigenetic alteration of the genome and its regulating effect on the expression of genes and transposable element movement, may aid rapid adaptation in situations where the genome's adaptation is believed to be too slow to keep up with the rising pace of anthropogenic environmental change (Anderson et al., 2013).

Seagrasses and macroalgae face several threats as a answer of the present climate changes. The physiological responses and durable viability of early life stages (such as seeds and spores) are closely intertwined with their genetic along epigenetic characteristics. Environmental shifts also impact the advantageous relationship among microbiota communities and their environments. Changes in macrophyte biochemistry can have far-reaching effects on the trophic levels that depend on seagrass-derived organic material for food, including a drop in energy transfer due to diminished carbon fixation and a precipitous drop in essential fatty acid synthesis. By combining physiological and ecological information in main productivity models along with ecological niche models, conventional modelling approaches can provide a more comprehensive view of the future constraints that these crucial foundation species will have to overcome. Research on seagrasses along with macroalgae would benefit greatly from a multi-disciplinary approach that takes into account epigenetic, genetic, as well as microbiome amounts of intra-specific variations and ecotypic differentiation to get a more comprehensive comprehension of variation in phenotype as well as more feasible change scenarios that are crucial for mitigation and conservation (Anderson et al., 2013).

1.10.4 Global Warming – Relationship with Climate Change

The rapid increase in warming worldwide is apparent via the escalating mean atmospheric and water temperatures, the extensive disintegration of ice-sheets, and the elevation of the oceans, all of which were reported in the "Synthesis Report of the Fourth Assessment Report on Climate Change" published by the "Intergovernmental Panel on Climate Change (IPCC)" in 2007. Climate change is real and unprecedented, as stated in the

2001 “Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)”. To put it simply, climate change is the gradual, overarching alteration of Earth's climatic conditions that has been brought about mostly by human activity, in this case in the form of manmade greenhouse gas emissions. The term “climate change” is defined as “a change which is attributable directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods” in Article 1 of the “United Nations Framework Convention on Climate Change” (Mukherjee, 2012).

The implication of this definition’s interpretation is as follows:

a) That changes in the global climate are mostly the result of human activity.

b) That the composition of the atmosphere around the world will shift as a result of climate change, with consequences for the maximum allowable levels of various gases.

c) That it’s not a result of natural causes.

However, it must be remembered that the observable effects are not the direct consequence of the present concentrations of greenhouse gases but rather the result of the long-term effects of such emissions that have occurred since pre-industrial times. After the Industrial Revolution, the world’s average temperature rose by 0.80 degrees Celsius (Secretariat, R. S., 2008). An additional rise of roughly 0.7 degrees Centigrade is predicted in light of the present trend of warming temperatures. If it manages to stop the process of global warming today, the temperature will still rise by around 1.5 degrees Celsius by the end of the century at the latest (Mukherjee, 2012).

1.11 “Foreseeable Impacts of Climate Change”

1.11.1 Impact upon productivity

There is no definitive answer to this question from studies regarding the Eco physiological reactions of maritime micro-algae, their photosynthesis capability or development, or the variations in the sea related to increases in carbon dioxide and global warming (Beardall and Raven, 2004). Nonetheless, the chain reaction of natural repercussions from these impacts likely reflects the intricate interactions that may occur between the components of climate change as well as other connected variables, such as nutrition availability. As expected, throughout the era of stratification, there was an increase (Richardson and Schoeman, 2004), primary production in the ocean might be considerably altered by changes in either large- or small-scale phenomena (upwelling, fronts, coastal currents). Although counter-processes may be formed, this impact has the potential to propagate to the formation of shoreline environments, populations of 'macroalgae', and phanerogam areas. The growth of phanerogam fields and marine macroalgae communities, both of which are restricted in their productivity by the amount of carbon dioxide (CO2) available to them, may be stimulated by a rise in atmospheric and surface water CO2 partial pressure.

1.11.2 Impact upon species distribution

Many species' distributions, both pelagic as well as benthic, are likely to shift as a result of alterations in the thermohaline characteristics of the deep-sea and additional correlated phenomena. Many species' ranges would shift as a direct result of a rise in average temperatures "(Boalch 1994, Southward et. al., 1995, Alcock 2003)". Depending on how climatic shifts affect currents and seasonality, the rate of change might pick up or slow down. In addition, not all areas of the coast will see the same changes, such as a decrease in species production. No examination of the likely trends due to climate change has been performed, however, certain species may see an uptick.

1.11.3 Impact upon fish populations

Climate change has a direct impact on marine recruitment, an important step throughout the life cycle for commercially fished species. Sea currents are affected by atmospheric circulation changes, which in turn can impact the movement and success of larvae and juveniles. Modifications that affect the trophic chain may occur at a larger scale. Indirectly, oceanic ecosystems are also impacted by climate change. The potential consequences include a temporary disruption to the creation of marine life at the primary as well as the secondary levels. This disruption could subsequently affect the availability of nourishment for fishing pupae, the pace at which new individuals join the community, and ultimately the development of the entire fish species (GLOBEC 2003, ICES 2003). Included in the changes described are transitions between different types of circulation, which can occur quickly at times, it has the potential to cause shifts in both the pelagic as well as benthic communities. As an illustration, (Chavez et al., 2003) labels them the “sardine regime” as well as the “anchovy regime”.

1.11.4 Impact upon marine farming

There is still a lot of doubt about how maritime productivity will shift in the future. Phytoplankton productivity shifts due to hydrologic changes are not the only cause of concern (Richardson and Schoeman, 2004), have been identified, the predicted consequences of marine farming continue to be highly unknown and subject to significant uncertainty. It is unlikely that changes in productivity will have a significant impact on the cultivation of species that serve as dietary supplements, as adjustments to the diet should be adequate to make up for such shifts. If environmental change goes beyond the species’ physiological limitations (for dissolved oxygen, temperature, and salinity), then serious problems may arise.

1.12.1 “Climate Change and Maritime Trade in Indo-Pacific 2040”

Looking forward to the year 2040, the Indio-Pacific area emerges as a prominent area of notable transformation, with environmental variables taking place among the world's major

issues. In the midst of changing worldwide financial and political situations, the phrase Indo-Pacific has become more important, referring to the two regions the Asia Pacific and the Indian Ocean Region. The study examines the probable effects of global warming on marine commerce in the Indo-Pacific area, including factors such as temperature rises, shifting rainfall trends, and growing uncertainties about the environment. In a time period expected to see increased human-caused global warming consequences, the complex connection between ecological alterations and geopolitics circumstances becomes very significant. The Indio-Pacific region, which is already of great importance for global commerce and fuel transportation, is expected to see significant transformations in the twenty years to come. Marine shipping routes in this extensive area perform a crucial role in both financial security and the geopolitics agendas of key world powers. As global warming speeds up, it presents additional difficulties such as increases in water levels, alterations in ocean circulation, and increasingly regular severe storms. Consequently, the capacity of marine routes to withstand and adjust to these problems becomes crucial. The study explores many possible outcomes for the year 2040, analyzing how climate-related alterations could affect the Indo-Pacific marine region. The consequences for transportation routes, which are widely recognized as reliable pathways for international trade, are magnified in an environment where climatic conditions change frequently. Furthermore, as countries establish themselves throughout the Indo-Pacific area, their financial and diplomatic objectives grow closely connected with their obligation to adjust to and reduce the impacts of global warming. The study tries to provide a future-oriented viewpoint that goes beyond existing time limits by analyzing the Indo-Pacific basin in the year 2040. The study aims to improve comprehension of the way the complex interaction between warming temperatures and shipping will influence the tactical goals of significant world nations in an unresolved and opportunistic the future. The result can be achieved by combining future weather estimates, international patterns, and forecasts of the economy (Anadi, 2024).

1.12.2 Climate – Change Outlook in the Indio – Pacific Region by 2040

On the year 2040, the Indo-Pacific area will begin to see extreme weather situations marked by an increase in sea level rise (SLR), mostly caused by warming temperatures. At the moment, worldwide temperatures exceed one degree Celsius in comparison to the beginning of industrialization and are projected to rise to two degrees Celsius by the 2030's. Such presents substantial threats to coastline nations in development. There are worries about the potential for a two degrees Celsius rise in heat, which is considered a crucial point when the hazards of warming temperatures grow significantly. This rise might happen by the 2050s, contingent upon the amount of GHGs released into the atmosphere in future decades. The complex interplay of factors involved in climate change leads to significant alterations in the average ocean level in the Indo-Pacific region. The phenomenon is largely caused by the growing volume of the seafloor owing to changes in the retention of fluids on property, added weight by dissolving ice caps and icebergs, as well as isostatic adaptation, greater hot water material, and generated by human's shoreline depression. Recent data suggest that the median worldwide sea level has been rising at a rate of around four centimetres per annum (Anadi, 2024).

The need for immediate responses on global warming is emphasized by the swift disappearance of both polar and mountain ice caps. This increases the risk of increasing sea levels in the future (ESLs) and raises the danger of hurricanes in the Indo-Pacific area by 2040. Studies suggest that alpine and Antarctic glaciers may see a decrease in volume of ice in the range of eighteen to thirty-six percent by the conclusion of the millennium. The accelerated disintegration of glaciers in Greenland and Antarctica adds to further elevation of sea levels. The IPCC 2019 assessment emphasizes the continued reduction of ice in the Greenland Ice Sheet. Estimates indicate that there might be an enormous spike in melting ice beyond 2060, leading to a contribution of roughly 0.5 cm per year to global sea level rise by 2100. The study also emphasizes the escalating thawing of the Antarctic Ice Sheet, predicting a possible abrupt

spike in glacier depletion after 2060. This may potentially add around half a centimetre per year to the increasing trend of sea levels worldwide by 2100. The rapid increase caused by this speed poses a substantial threat of floods in coastlines, highlighting the urgent need for urgent action to address climate change (Anadi, 2024).

According to the International Monetary Fund, if steps to combat global warming are not implemented, some fifty-nine million individuals in Southeast Asia as well as the Pacific Islands would be forced to leave their residences by Mid-century owing to the effects of global warming. The tropical Pacific Islands, particularly those with lowlands such as the atolls or those with elevations just a few meters above the ocean's surface, have been the first locations to experience the impacts of these phenomena. The present unparalleled pace of "sea-level rise (SLR)" over a span of five thousand years presents risks of inundation, coastline degradation, and waves caused by cyclones to these susceptible archipelago ecosystems. Projections suggest that the median sea level rise (SLR) would range from twenty-five centimetres to fifty-eight centimetres by the middle of the 21st century. That poses a catastrophic situation for island located just barely below the level of the sea. As the likelihood of a 2-degree Fahrenheit rise in warming worldwide from earlier in history increases, it is expected that a significant proportion of barrier islands in the Pacific Islands area would experience significant deterioration. That will have a detrimental effect on aquatic creatures that depend on these natural environments. Scientists have discovered that all the tropical island systems analyzed are at risk over the whole century to come, as a result of several environmental predictions. Under the greatest probable circumstances, the pace of sea level rise (SLR) could quadruple, leading to the irreversible depletion of the supply of underground water in the decades to come. Consequently, this could render islands more vulnerable over the later part of this century. Under an increasingly gloomy climate-change situation, a sea-level rise of 1 meter would cause islands to become unstable over a period of twenty to forty years. This could result in numerous

populations being exposed to amounts of danger that are considered unacceptable by the time period 2060. Moreover, as stated in the Association of Southeast Asian State of the Environment Assessment, the Association of Southeast Asian Nations (ASEAN) area is projected to encounter adverse impacts on important industries like farming, watersheds, coastlines, and human well-being. Organized sea level rise (SLR) by 2050 demonstrates a substantial variation among countries, with a typical rise that ranges from a minimum of seven centimetres for Brunei Darussalam and Indonesia to a remarkable 378 cm for Vietnam. Simultaneously, forecasts of temperatures in various Representative Concentration Pathways (RCP) scenarios suggest that the member nations of ASEAN will experience a rise in typical deaths due to heat stress per a thousand km2. Specifically, the nation of the Philippines is projected to have a median of 5.50 per cent to 5.68 casualties, while Vietnam is expected to have a standard of 7.83 to 7.86 dying by the year 2050 according to the respective RCP 4.5 and RCP 8.5 circumstances (Anadi, 2024).

Furthermore, in the Indo-Pacific area, the "El Niño–Southern Oscillation (ENSO) continues" to have a substantial impact, particularly on the organic fluctuations of tropical cyclones (TC). Estimates indicate that the area will have a higher occurrence of tropical cyclones (TCs), with an expected rise of around twenty to forty percent throughout prospective El Niño times throughout the whole western the Pacific Ocean, comparing to the current occurrence. Temperature simulations suggest that as temperatures rise, there is a greater chance of more intense tropical cyclones (TCs) and higher worldwide rainfall. Specifically, the Pacific basin is expected to see stronger TCs, resulting in significant gusts of winds and flooding. The area is forecasted to undergo continuous becoming warmer, with weather conditions estimated to climb by near 0.7°Cs by 2030, and additional rises of about 0.8 degrees Celsius by 2050's under an extremely low pollution instance, and up to 1.5 degrees Celsius in an extreme pollution forecast. Sea level rise (SLR) is projected, with estimations varying between 0.09 to

0.18 meter by 2030 and subsequently increasing to as much as 0.63, respectively, m by the year 2070, with respect to different pollution assumptions. Although there is an expected decline in the frequency of tropical cyclones (TCs), their median strength might vary by minus five to + ten % under a two degrees Fahrenheit warming worldwide projection. The anticipated spike in the normal strength of cyclones, together with sea level rise and greater amounts of heavy precipitation, highlights the increasing likelihood of more severe effects from cyclones in the Indo-Pacific area by 2040 (Anadi, 2024).

The climate-change estimates for the Indo-Pacific area have important consequences for marine commerce. The increasing frequency and intensity of tropical cyclones, together with rising sea levels and severe storms, provide significant difficulties for coastal facilities and shipping in the region. Global warming has the potential to interfere with international commerce by changing the price of commerce, moving the benefits of different countries, and upsetting the interconnected networks of worldwide value chains. Studies suggest that an increase in temperatures by one degree Celsius is linked to a decrease in the annual exports expansion rate of emerging economies by about two to five percentage percentiles. The number nineteen is enclosed in square brackets. According to the IPCC, if People continue with our present behaviours, so that may hit the crucial barrier of 1.5 degrees Celsius to two degrees Celsius of heating over the next ten years, namely by 2030. The Earth, which is currently seeing extreme temperatures, may potentially experience a remarkable rise in the average worldwide climate by up to 5.5°C. Despite swift action, it is expected to need a period of between twenty and thirty years, which is comparable to an entire another, to repair the existing unfavourable patterns. since a result, the forecast for the Indo-Pacific region area by 2040 is grim, since a warming climate is expected to have more negative effects on marine commerce. Due to the higher danger of hurricane effects and sea level rise, it is crucial for shipping companies to implement planned adaptation and mitigation strategies in order to provide secure and

convenient ports for trade by sea. Moreover, the possibility of climate-induced catastrophes causing disruptions in world supply chains highlights the need of gaining a thorough knowledge regarding how these changes in climate might affect the prospects of trade by sea in the Indo-Pacific region (Anadi, 2024).

1.2 Research Problem

The "Climate change impact on the marine industry" study topic is complex and of great importance. The latest phase of environmental instability has begun, and it is mostly due to climate change brought about by human-caused events such as the release of greenhouse gases. Changes to the seas and, by expansion, the maritime sector, are one of the biggest and most immediate repercussions of this worldwide issue. Increases in sea surface temperature, ocean acidification, rise in sea levels, and extreme weather conditions are having a profound impact on the marine environment, which is posing serious threats to an industry crucial to international commerce and the well-being of countless people throughout the world. To create tactics to promote adaptation and mitigation, researchers must first have a better knowledge of the scope and nature of these effects, as well as the vulnerabilities faced by various sectors of the maritime industry. Due to the economic and ecological importance of the maritime sector, as well as the necessity of protecting its long-term viability and adaptability in the face of an ever more unpredictable environment, addressing this issue is essential. This study aims to shed light on how marine regulations, procedures, as well as innovation can be enhanced in response to climate change. Its ultimate goal is to ensure that the maritime sector can sustainably contribute to global economies without jeopardizing the ecological systems that rely on it.

1.3 Purpose of Research

The study of "Climate change impact on the marine industry" is of vital importance on a worldwide scale because it addresses the intersection of environmental preservation,

economic security, and social welfare. There can be no doubt that human-caused climate change is a worldwide emergency with severe repercussions for the maritime ecosystem. First, the study purposes to fully comprehend the various belongings of the changing weather on marine commerce, elucidating the risks and vulnerabilities within various sectors; second, it aims to lay down the foundation for effective mitigation and adaptation techniques, providing a road map for industry resiliency; and third, it aims to contribute to the worldwide fight against climate change as well as underwater ecosystem safeguarding, recognizing the marine in the worldwide effort to fight against climate change. This study's overarching goal is to shed light on how the marine industry is being affected by climate change and to provide concrete recommendations for how to mitigate these effects, all of which will help ensure the long-term health of the oceans, the well-being of the coastal neighborhoods, and the continued success of the marine sector.

1.4 Significance of the Study

The "Climate change impact on the marine industry" is a topic that spans several important subfields with worldwide repercussions, making it an important area to investigate. Important as it is to solve the pressing environmental catastrophe of climate change, this study is also of great value in and of itself. The study's findings provide crucial information on the oceans' health and resistance to climate change by examining the properties of weather alteration on the marine area. In addition, the maritime area is crucial to the global economy as a whole, making enormous contributions to the flow of goods and services throughout the world. Financial security and the lives of numerous communities throughout the world, especially those in coastal areas, depend on this sector remaining resilient in the expression of environment alteration. Additionally, this study acts as an impetus for the growth of adaptation as well as mitigation techniques that can aid the maritime industry in navigating the choppy waters of changing climates while reducing the amount of damage done to the environment. In

this way, it promotes the development of environmentally friendly procedures, cutting-edge technology, and effective policy suggestions that safeguard businesses and add to larger efforts to preserve the natural world. Since the research is in line with societal goals like reducing greenhouse gas emissions, protecting marine ecosystems, boosting the availability of nutritious food worldwide, and fostering social justice, it is ultimately an important endeavor with significant consequences for the future of the planet, not just for the industries involved.

1.5 Research Purpose and Questions

1. What effects does climate change have on the maritime sector?
2. How does climate change affect the movement of oil, and how does it affect maritime transportation?
3. How to investigate how climate change affects agricultural output and how it affects maritime transportation?
4. What effect does sea level rise have on coastal erosion and accretion?
5. What steps are being taken to adopt the possible harm that weather shift could cause to the maritime industries?

The consequences of global warming are now altering the lifestyles of millions of individuals in nearly all parts of the globe. Based on the most recent climate simulations, future predictions indicate that the world's mean temperature might increase by up to 5.6℃ compared to before the Industrial Revolution if the amount of carbon dioxide (CO2) in the environment is quadrupled. This is frequently referred to as 'Equilibrium Climate Sensitivity'. The ramifications associated with a substantial increase in heat would be disastrous for societies of humans. In 2015, over 180 nations endorsed the Paris Agreement, committing to limit global warming to a level much below two degrees Celsius. The objective is to strive for an upper limit of one and half degree Celsius, with the intention of mitigating the most severe consequences of warming temperatures. The year 2018 report "Special Report on a Warming

Rate of 1.5°C by the United Nations Intergovernmental Panel on Climate Change (IPCC) emphasized that in order to keep the temperature rise below 1.5°C, carbon emissions resulting from human activities need to decrease to approximately half of their 2010 levels by 2030 and achieve a net zero level by 2050". This is a very difficult task that needs immediate and radical response in every area of the global economy. The power sector is presently spearheading this transformation, mostly driven by the growing popularity of green energies such as wind and sunshine. This is due to the latest improvements in the effectiveness and availability.

The relationship between the environment and the shipping sector is closely interconnected. The shipping sector accounts for around 8 to 10 percent of global emissions of carbon dioxide, positioning it as one of the largest contributors to carbon pollution worldwide. Global warming, in turn, leads to many consequences, including harm to buildings and even small-scale issues such as guaranteed bond disputes. It is essential for experts in logistics to comprehend this process, in addition to the procedures for disrupting it. By examining the intricate and interdependent relationship between transporting goods and global warming that can evaluate strategies to halt the progression before it reaches a critical point (Englert, 2017, pp. 5-6).

CHAPTER II:

LITERATURE REVIEW

2.1 Review of Literature

2.1.1 Review related to the climate change effect on the maritime industry.

Ezinna, Nwanmuoh and Ozumba (2021, pp. 98-105) determined that fossil fuel, the lighthouse of industrialization, produces the most carbon dioxide emissions. When it comes to greenhouse gases, carbon dioxide emission was the primary culprit in global warming and the negative effects of changing climate. The "United Nations General Assembly in 2015 adopted 17 Sustainable Development Goals (SDGs)," with "goal 13" being a call for climatic action to reduce overall heating to two degrees Celsius above preindustrial directs or one and half degree Celsius by 2030. This was done in light of the enormous effect that weather adjustment would have on the world. More than 80% of international trade occurs on water, making shipping a major consumer of "Heavy Fuel Oil (HFO)" and a significant contributor to world carbon dioxide emissions (2.7%). In light of this, the aim of this research was to measure how far along the world was in its pursuit of decarbonization for sustainable growth in the marine sector, with a special emphasis on international shipping. For this study, it used a documentary approach, and Win-Win Solution was the theoretical underpinning. To assesses whether or not the maritime sector would be able to meet its green shipping objective by 2030, the research reviewed current initiatives to reduce carbon emissions from shipping.

Wan et al., (2018, pp. 428-435) estimated that rising global freight volumes might raise ship-basis "greenhouse gas (GHG)" emissions by as much as 250% from 2012 levels by 2050. However, worldwide legislative agreements to control GHGs were weak, in part because technical solutions were still costly and in part because critical industry backing was missing. The "International Maritime Organization (IMO)" passed "Resolution A.963 (23) in 2003" to

control "carbon dioxide (CO2)" emissions from ships by operational, technological, and market means. Despite of this, advancement has been sluggish and unsure; there was no set goal for reducing emissions and no set action plan. Despite spite of this, advancement has been sluggish and unsure; there was no set goal for reducing emissions and no set action plan. Yet, it could not see a comprehensive plan until 2023 at the earliest. The policy analysis here looks back at the development of technological, operational, and market-based pathways and the debates that have surrounded them. It asserted that 1) based on-performance index, while well-intentioned, has loopholes impacting meaningful reductions in CO2 emissions determined by technological developments; 2) gradual steaming to expurgate energy use stands out between operational approaches thanks to its instantaneous and apparent results, but with the slow pace in practice, this particular source has restricted potential for reducing emission; and 3) without a technology-savvy transporting industry, an approach based on markets would not be effective. Drastic emission reductions must take imperative that drastic emission reductions take place as quickly as possible to offer the maritime industry a fair and proportional opportunity to impact to the attempt to keep environment shift below 2 °C.

Kelly, Pecl and Fleming (2017, pp. 21-28) recognized the critical worldwide need for sustainable ocean administration in the face of threats such as climatic change, overfishing, pollution, and a growing list of other consequences. While marine conservation efforts and marine protected areas have both grown in recent years, managing the oceans has been slower to include and involve people in its growth than other, more land-based industries. While the phrase "social license to operate.” Commonly used on land, its meaning and applicability in maritime contexts were still developing. The purpose of this analysis was to compile and synthesize recorded cases of social licenses within the marine domain to gain insight that may guide the growth of societal licenses in future years. The study found that social license is still a new idea in the maritime industry, but that it has promising potential in this setting. The

concept of "social license to operate" has emerged as a central idea in the expansion of the marine sector and the exploitation of marine resources, especially in the areas of dialogue and stakeholder participation. This research has uncovered new questions and areas of focus for this field.

Allison and Bassett (2015, pp. 778-782) addressed how the impacts of climatic change on the oceans were less obvious than those on melting ice sheets, but yet have significant ramifications for all human communities, not just those located on the shore. The seas were crucial to accomplishing sustainable development goals due to rising public concern over the oceans' destiny and rising business interest in producing blue riches. Both on land and in the ocean, studies of climate change were dominated by human-nature systems analyses that make strong use of economics but only minimal use of the study fields that interact least with the fields of natural science. Future “Intergovernmental Panel on Climate Change (IPCC)” evaluations of marine and coastal change might benefit from insights from maritime histories, ethnographies of coastal civilizations, and the political geography of the seas. The range of viable responses to climate change in various cultural, social, and political contexts would be enriched by the inclusion of non-academic modes of experiencing and knowing, such as Indigenous knowledge and the moral perspectives of major global faiths. Making the seas more prominent in climate change policy requires a deeper knowledge of the human components of ocean climate change.

Bows-Larkin (2015, pp. 681-702**)** resolved that decarbonization must occur across all economic sectors to prevent a 2ºC temperature rise. Nonetheless, significant governmental efforts to mitigate growing CO_2 from global air travel and shipping remained woefully inadequate. Since they were both given equal weight in the "United Nations Framework Convention on Climate Change (UNFCCC)," they were frequently discussed as though they were fronting the same threats and can even have an effect on one another's strategies for

reducing their respective impacts. They differ significantly from one another in both their strengths and flaws. This study helped to illuminate these distinctions so that they may be expanded upon to enhance future policy discussions. The study provided a quantitative analysis of the "2ºC" paths for various industries, demonstrating the pressing urgency of accelerating mitigation efforts. A shift in "aviation mitigation policy" is cited as an example of a recent event that has directly influenced efforts to reduce CO_2 emissions from shipping. The study concluded with a comparison of mitigation's prospects and obstacles. The essay concludes that the shipping industry has several challenges that prevent it from becoming more environmentally friendly in the near and medium term due to its complexity. However, the less complex aviation industry is placing too much faith in emission trading to accomplish CO_2 reductions with 2ºC targets. However, the solution itself is still divisive and unpopular: demand management to limit warming to below 2ºC.

Holbrook and Johnson (2014, pp. 703-715) explained how crucial commercial marine fishing is to Australia's coastal towns and how it boosted the country's “Gross Domestic Product (GDP)” tremendously. Yet the fishing industries of Australia face serious threats from climatic change both now as well as in the future. If the fishing sector makes better use of specific data, it may lessen the adverse outcomes of climatic change and make the most of the positive opportunities it presents. If the fishing industry, and especially wild capture fisheries, were to survive and thrive overall, they will need to develop and implement effective adaptation techniques. Better weather as well as seasonal climate projections and their effect on target species, and a deeper understanding of species limitations, were just a few examples of how knowledge about projected long-term shifts in species distributions might inspire adaptive responses. This study reviewed the latest developments in research addressing Australia's priorities regarding commercial marine fisheries' responses to current as well as anticipated

future impacts of climate change, and it also takes into account barriers as well as adaptation options for the management of fisheries over the near-term organizing horizon of 5-7 years.

Vergara, McKesson and Walczak (2012, pp. 333-345) highlighted scientists' near-unanimous conclusion that human being activities played a role in global warming, as well as the many approaches nations were taking to cut down on their carbon dioxide output. The marine transportation industry must shoulder some of the blame for implementing new, creative solutions on a worldwide basis. The authors used the stabilizing wedge model to predict the energy use and emissions from various forms of maritime transportation in 2050 and to investigate potential activities and technologies from which policy recommendations for environmentally friendly marine propulsion might be derived. The marine sector is responsible for 3% of the worldwide emissions reductions, or around 44 GtCO2/y, needed to maintain a temperature rise of not more than 2° Cover preindustrial levels. It offered many technologies, such as mission refinement, resistance diminution, prime mover as well as propulsion inventiveness, and new fuels, to help achieve this sector's reduction objective of around 1.67 GtCO2/y by 2050. The authors discovered that the target is only partially attainable as well as propose that the shortfall be met by terrestrial synfuel refineries that utilize carbon dioxide from power plants powered by coal and hydrogen generated from renewable energies, a strategy that would lengthen the useful life of conventional engines of motion. It will have to wait until appropriate technology is implemented to cut emissions within the maritime industry.

Miola, Marra and Ciuffo **(**2011, pp. 5490-5498) calculated that even without a policy in place, there is a considerable opportunity for abatement in the international sea transport industry, and that there were technological improvements that would provide financial benefits. Encourage the industry to decrease its “Greenhouse gas (GHG)” emissions, this study examines in depth the potential and limitations of policy alternatives presently being considered at the international level. For the maritime transportation industry in particular, the "European Union

Emission Trading Scheme" and other market-based international initiatives offer a window of opportunity to green its operations without imposing undue hardship. However, several challenges that must be overcome to construct a regional policy, including on a European scale, for the international marine transport sector. There are several factors to consider, such as the cost of transactions, the number of different types of ships, the amount of their emissions, and how much fuel they use. If global market-based policies were put into place, many of these issues might be resolved. This research provides a thorough evaluation of the policy instruments currently under discussion to lessen the influence of the "international maritime transport" business on the atmosphere by analysing the economic theory, legal concepts, technological options, and political framework upon which decisions in this area are based.

Sumaila et al., (2011, pp. 449-456) emphasized that maritime ecosystems, fisheries, and fish stock are all likely to be impacted by climatic change. However, there exist still significant breaks in the learning of the entire scope of implications weather shift may have on the financial aspects of fishing. Research into the impacts of global change on fisheries is required, both from inside and outside of existing academic disciplines. Currently, there is a lack of comprehensive research on the impacts of climatic change on fisheries, with much of the current data coming from a small number of well-studied places that may be less severely impacted by climate change. It needs a better knowledge of how catches and seafood protein availability, revenues, fishing expenses, employment and incomes, resource rent, and other economic operations resulting from the world's fisheries might be impacted by the biophysical implications of changing climates on the worldwide ocean. There has to be study on the global influences of changing temperature on fisheries and how that will affect the consumer surplus that may be earned from the world's fisheries. If greenhouse gas emissions were lowered, the biological implications of changing climate on fish supplies would be reduced, and the

economic costs associated with this phenomenon would be reduced as well. Add, if emissions were lowered, the price tag for responding to environmental issues would go down as well.

Cavanagh et al., (2021) in their article, Future Risk for Southern Ocean Ecosystem Services under Climate change published in Google scholar. According to the authors, the Southern Ocean sustains ecosystems of significant worldwide significance. The eventual need for and availability of such amenities will be impacted by warming temperatures and the actions of humans like as travel, fishing for seafood and exploration. In the study, the authors combine previous evaluations of the present condition and anticipated future climate-induced alterations in Southern Ocean ecosystems. They also examine the possible impacts of these modifications on the delivery of ecosystem-based services. The investigators extensively examine three essential amenities "(the 'blue carbon' route, the Antarctic krill fishery, and Antarctic tourism)", meticulously tracking the repercussions of global warming from its material catalysts to its impacts on life, and ultimately assessing the advantages to humanity. The study analyzes possible factors other than environment that might cause changes, evaluate now and in the future for these amenities, and examine the primary international and local policy approaches that might be utilized to mitigate threats associated with the supply of these amenities in an environment that is evolving. The study furthermore constructs a structured depiction of the system of connections involving the range of prospective factors and the range of offerings, offering a structure to comprehend the intricacy of this system and its inherent feedback structures. In order to ensure efficient management tactics in coming years, it will be necessary to give more attention to the connections and relationships between factors that promote changes and the functions provided by ecosystems.

Han (2010, pp.7-29) studied the effect of pollutant emissions from ocean-going ships on human health as well as the environment. The goal of this research is to assess the efficacy of existing pollution controls in the maritime industry. There were three primary avenues for

reducing emissions from ships on the high seas: technology advancement, operational adjustments, and market-based measures. Shipping firms have also emphasized an emphasis on environmental policies with the end goal of increasing their eco-efficiency and corporate social responsibility. The following were some of the policy consequences of this research. The first step is to mandate that the public be made aware of the necessity and urgency of environmental protection in the maritime sector. The second step is to discover the current state of the ship as well as port area pollution and create an evaluation methodology for the environment. Third, an integrated strategy is a better way to reduce air pollution from the maritime industry. Last but not least, the cooperation of stakeholders is essential for the effective avoidance of environmental damage in the shipping business.

2.1.2 Review related to the climate change effect on oil and marine transportation.

Watanabe et al., (2023, p. 100418) developed a country-specific "life-cycle assessment (LCA)" of many fuel conversion paths in Europe, including those involving advanced biofuel production and grid-connected "Power-to-X (PtX)" fuels. The future climate change reduction efforts were evaluated by estimating the availability of biomass resources (including agricultural and forest leftovers and the subsequent generations' crops for energy from abandoned farmland), the power mix, and a projected LCA with an eye toward the future. Results showed that nations with a carbon content of the energy combination below "100 gCO2eq kWh 1" were the only ones where PtX fuels had a chance of achieving well-to-wake GHGs concentrations lesser than that of black gold. To reach the higher-level Fuel EU Maritime objective, PtX would need to be linked to electricity sources with a carbon intensity of less than "ca. 17 gCO2eq kWh 1," which is attainable for greatest public power mixtures in "Europe by 2050" if green power supplies were installed on a substantial scale. "Drop-in biofuels and hydrogen-based biofuels" exhibited a greater prospective for emission reduction when using biomass scraps as opposed to specialized energy crops. Energy supply potentials from all

"renewable and low-carbon fuels (RLFs)" in Europe were estimated to be between 32% and “149% of the present annual fuel use in European marine transport”. In Europe, the present well-to-wake shipping emissions might be reduced by up to 184% if all RLFs were equipped with carbon capture and storage systems.

Yacout, Tysklind and Upadhyayula (2021, p.105763) discussed the forest-based biofuels as a substitute to conventional energy sources in maritime transport seems like a tempting option given the discussion of international shipping as a key contributor to variations in the Arctic area owed to the produced inflight releases from maritime fuel burning. Its long-term viability, however, required the use of system analysis principles. Estimate the purpose of estimating the environmental implications of producing and utilizing two forest-based biofuels, a "life cycle assessment (LCA)" was conducted. Biodiesel and bioethanol were two fuels that may be used by ships, and they were both developed from pulp and paper factories. They were contrasted to the fossil fuels "Marine Gas Oil (MGO)" and "Heavy Fuel Oil (HFO)" in use in the maritime transport sector at the time. It also investigated how the environmental implications of Arctic shipping may change if fossil fuels were replaced by biofuels in the 2030s and 2050s, two future projection scenarios. The findings emphasized the significance of adopting a comprehensive perspective while utilizing biofuels. The production and consumption of "bioethanol (BE)" derived from forests had a much smaller impact on the potential for "climate change (CC)," but a much larger impact on "Human toxicity non-cancer effects (HTX)," "Human toxicity cancer effects (CE)," "Particulate matter (PM)," "Photochemical ozone formation (POF)," "Acidification potential (AP)," "Terrestrial eutrophication (TE)," The potential AP was cut in half when biodiesel made from trees was used instead of HFO.

Monios and Wilmsmeier (2020, pp.853-872) highlighted the substantial amount of work that has been created in recent years on port adaptation to climate change. Adaptation

efforts have stopped for the same reason that climate change mitigation efforts had stalled: the collective action dilemma, in which both private and public players avoid commitment to critical expenditures. The idea of 'deep adaptation,' which emerged recently, posited that society should prepare for disruptive and insurmountable levels of change in the climate, bringing malnutrition, destruction, migration, disease, and war, rather than merely incremental difficulties that can be adapted to piecemeal. It is well established that modest incremental policy adjustments were not enough to mitigate and vary to climatic change, but current port as well as shipping predictions continue to expect unbroken expansion. This research stated that participants in the marine transportation industry need to think about more than the dangers that have been recognized so far and should also get ready for an earlier adaptation timeline.

Messner (2020, pp. 195-208) examined the possible effects of air emission particles, with a focus on "black carbon (BC)", as a result of increased Arctic maritime traffic. As a result of more frequent passages in the Arctic Ocean as a result of melting ice, black carbon emissions through the combustion of fuel oil will have negative effects on the environment. Greater black carbon emissions to oil for fuel combustion by shipping may have an observable local warming effect, according to studies. This warming would result after the double belongings of dark carbon absorption of astral energy and reflective power decrease due to statement on ice and snow. The health impacts of local haze should be mitigated by the "International Maritime Organization (IMO)" requirement to reduce sulfur satisfied in container oils by 2020, but there is still a lot of mystery surrounding the reduction of black carbon emissions and, by extension, the mitigation of the broader influences of growing transport on the Arctic weather. Strategy variations in policy will be necessary in the future, and they include cleaner fuels, more efficient engines, and tighter regulations on particulate matter released by Arctic boats.

Schnurr and Walker (2019, pp.1-9) highlighted maritime transportation's fast-increasing demand, along with the possibility that it may account for up to 17% of worldwide

"greenhouse gas (GHG)" emissions by 2050 if measures were not taken to curb the trend. To reduce emissions of “greenhouse gases (GHGs)” by the "International Maritime Organization greenhouse gas (IMO GHG)" by “50% from 2008 levels by 2050, the current marine transportation fleets utilizing bunker and heavy fuel oils were being phased off and replaced with new ships powered by low-carbon fuels”. 2/3 periods from now, methods to mitigate energy usage (and hence emissions) in maritime transport will include innovative technologies, market-driven interventions, and operational adjustments. This unit of the study showed how the maritime transportation industry was already making strides toward the use of low-carbon fuels such as “liquefied natural gas (LNG), natural gas (NG), biofuels, battery packs, wind, nuclear, solar power, and hydrogen fuel cell technologies” to minimize or eliminate emissions.

Benamara, Hoffmann and Youssef (2019, pp. 1-31) considered the importance of marine transport in meeting the worldwide sustainability challenge, systems of marine transportation that were safe, secure, energy – efficient, inexpensive, dependable, low – carbon, climate – resilient, and governed by rules have helped advance economically efficient, socially equitable, and ecologically sound growth. However, unsustainable maritime transport methods that results in extensive external costs need to be fully addressed for this function methods successfully. The “Sustainable Development Goals (SDGs)” and the “Paris Agreement on climate change”, both of which were currently being implemented as part of “the 2030 Agenda for Sustainable Development”, provide a fresh window of opportunity to harness the marine transport sector’s sustainability potential. To effectively utilize marine transport in furtherance of the goal of sustainable development, sustainability in terms of economy, society, and the environment criteria had to be completely incorporated and mainstreamed into applicable maritime transportation scheduling processes, policies, and investment choices. Key challenges at the crossroads of marine transport and ecological sustainability were identified, with an

emphasis placed on the sector’s role as a catalyst for a growth path that benefits people, prosperity, the environment, and efficient and appropriate partnerships.

Mocerino, Quaranta and Rizzuto (2018, pp.1005-1013) discussed that the global fleet will be required to implement stringent new pollution controls within the next several years. From 2020 forward, considerable reductions in anthropogenic emissions will be required to meet the goals of the Paris Agreement while maintaining the average increase in global temperature below 2ºC. The importance of maritime transport in shaping these policies cannot be overstated. The "United Nations Framework Convention on Climate Change (UNFCC)" is waiting for the IMO to announce its position on the Paris Agreement by the end of 2018. In this regard, recommendations were established during the most recent meeting of MEPC71. The research sought to analyse the current stance of the IMO on the topic within the framework established by the "IPCC's last Assessment Report, AR5" while waiting for regulation modifications in the maritime realm. In this article, it conducted a comprehensive review of the Third "International Maritime Organization (IMO)" research on "Greenhouse Gas (GHG)" (3O IMO-GHG's), which includes an analysis of the global fleet's GHG and non-GHG emission inventories from 2007 to 2012 and a projection of emissions from 2012 to 2050. The concluding section of the investigation will focus on the consequences of these pollutants, namely how they affect people's health and the natural environment.

Nian and Yuan (2017, pp.1579-1589) mentioned the "International Maritime Organization (IMO)" along with the idea that decarbonizing international shipping was a crucial and required step towards achieving a sustainable global trading economy. “Though many excellent studies have been conducted on various aspects of maritime transportation, such as ship construction, operation, maintenance, engine performance optimization, fuel options, disassembly, and recycling, the number of comprehensive level life cycle analyses (LCA)" on maritime transport was significantly lower than that of energy and goods

production. This deficiency underlined the necessity for more independent research to enlarge the LCA literature for shipping. It responded by suggesting a strategy that incorporates insights from the study of energy and manufacturing systems analysis into a new framework. The serial growth of a general process chain assessment framework benefited from this method since it maintained continuity in systemic and boundary definitions. The case study results indicated that the practice of "slow steaming" would not always be ideal and that tankers of all sizes might benefit by maintaining a speed of 12 knots as a benchmark optimal speed. Life cycle carbon emission parameters for transporting "1 tonne of crude oil over 1 km (mg-CO2/t-km)" were determined to be between 6 and 9 mg while touring at 12 knots over chosen routes connecting maximum oil export and import nations.

Crépin, Karcher and Gascard (2017, pp.341-354) showed the breadth of findings from the EC project "Arctic Climate Change, Economy, and Society (ACCESS)". The persistence of this research was to evaluate the primary effects of climatic change on the geophysical variables of the Arctic Ocean, as well as the indirect effects that these changes were likely to have on socioeconomic activities including transportation, maritime sea-food making, and resource mistreatment. Related questions of governance were also investigated. Based on these findings, many management instruments were created that will continue to exist when ACCESS ends. Most of the project's findings were consolidated here as rough answers to issues that arose throughout the project, and these findings will inform future research. In doing so, it provided context for the project's conclusions and for the several pieces included in this issue's special section.

Lister, Poulsen and Ponte (2015, pp.185-195) stated that shipping by sea is the glue that holds the international economy together. It was decisive to the development of the “global economy” and is an important driver of environmental degradation anywhere it is present, including in the air, water, and land. As a result, reducing shipping's negative effects on the

environment must be a top priority for governments. This research showed how international agreements, national regulation, a growing number of collaborations among stakeholders and benchmarking processes, and a preliminary usual of secluded requirements from “cargo owners to enhance selected environmental concerns” all contribute to the complexities of international environmental governance in shipping. It discussed the environmental protection industry's lagging standards and the "International Maritime Organization's (IMO)" ineffective and complicated attempts to orchestrate change. The “gorilla in the closet” effect seen in other industries has not been seen in shipping, even though the threat of increased regulation (and the implementation of genuine agreements at the level of the region on particular emissions) has been widely discussed. There is a growing lack of cohesion, coordination, and obstacles in the "Transnational Environmental Governance (TEG)" environment in the shipping industry. The adoption of novel company procedures was slowed despite the increased regulatory efforts due to industry uncertainty about compliance with regulations and the absence of harmonization of voluntary green shipping standards. Consumers and the general public did not have much of a grasp on the shipping industry's impact on the environment.

2.1.3 Review related to the climate change effect on agricultural output.

Lachaud, Bravo-Ureta and Ludena (2022, pp.321-332) examined a wide range of potential increases and decreases in rainfall in "Latin America and the Caribbean (LAC)" as a result of warming temperatures through the beginning of the era. Here, the study evaluated how temperature shift affects productivity as measured by "total factor productivity" (TFP). It gathers data obtained from the "University of East Anglia's Climatic Research Unit (CRU)", the "Intergovernmental Panel on Climate Change (IPCC)," and the "Food and Agriculture Organization (FAO)" on the cost of lost output due to a lack of viable climate adaptation strategies for “28 LAC countries over a 54-year period (1961-2014)”. In order to take into account variations in technical and partial output elasticities between countries, as well as

unobserved environmental variables, it calculated a "stochastic production frontier (SPF)" specification for the model with random parameters. According to the data, a TFP growth rate of 5% per year is the most important variable in explaining the variations in output. Between 2015 and 2050, climate change-related productivity losses were predicted to be between 9.03 and 12.7 percent. The cost of these production losses in the LAC region was estimated to be somewhere from USD 14.7 billion ($14.7 billion) to $31.4 billion (at the high end of the range) depending on the specifics of the case and the discount rate used.

Guo et al., (2022, p.106891) argued that there has been a major shift in agricultural output throughout the world as a result of climatic change. Therefore, it is essential to examine the effect of climatic change on agricultural production efficiency so that key agricultural regions throughout the world can adopt innovative technology to increase agricultural production's flexibility. At the same time that global food safety is guaranteed, the effectiveness of agricultural output may be increased. In this article, it used information gathered from 43 different nations between 1992 and 2018. It employed the "data envelopment analysis-Malmquist model" to estimate agricultural efficiency both with alongside without the influence of climate, and it compared the findings across time and space. The findings demonstrate that climatic conditions may lead to inflated estimates of crop yields. Agricultural output is positively affected by climatic conditions in "Sub-Saharan Africa and Latin America", but negatively affected elsewhere. Furthermore, the effects of the changing climate on technological development were larger than those on technical efficiency. This study concluded that relevant agencies ought to prioritize agricultural technology development in the face of climatic change and implement proper management with geographical location and climatic circumstances. As a conclusion, this article's study methodologies and findings serve as a benchmark for the expansion of agricultural output in the face of global climatic change.

Ozdemir (2022, pp.1-13) emphasized that short-term natural vulnerabilities to the worldwide availability of food were just as critical for developing nations as long-term ones, even though the fact that the long-term dangers were more complicated to manage and may need constant adaptation to climate change's effects on agriculture. The persistence of this research was to examine the short- along with long-term effects of climatic change on the productivity of agriculture in Asia from 1980 to 2016. However, only CO_2 concentrations were shown to be associated with agricultural production in the short term. The effects revealed that there was a long-term connection linking the efficiency of agriculture and climatic change factors. While this impact has a positive direction in the near term, it turns unfavourable in the long run, proving that atmospheric carbon fertilization does boost agricultural output.

Habib-ur-Rahman et al., (2022, p.925548) indicated that agricultural productivity in food-poor places was threatened by climate change, particularly in Southeast Asian countries. “Drought, heat waves, irregular and strong patterns of rainfall, storms, floods, and newly emerged insect pests” were only some of the climate-driven extremes that have harmed farmers' livelihoods. Predictions of the future climate suggest a rise in average temperature and the likelihood of more intense, but unpredictable, downpours. At the same time, climate unpredictability makes it difficult to anticipate climate extremes. Mid-century (2040-2069) projections for Pakistan indicate a 2.8ºC increase in maximum temperatures and a 2.2ºC increase in lowest temperatures. Optimizing climate-smart as well as resilient agricultural methods and technologies for sustainable production is essential for managing the adverse impacts of climate change scenarios.

Yadav, Jaiswal, and Sinha (2021, pp.80-83) examined the impacts of climate change on farming and how to adapt to it. Harvest rates, CO2 enrichment, and increasing temperatures were only a few of the many elements that have been reported as an outcome of climatic variation. The balance of crop output, water productivity, and accessible soil water all play a

significant role in a successful agricultural system. Widespread agreement exists that the amount of groundwater and its water status in the soil will be significantly impacted by the aforementioned variations in rainfall and temperature that will be (were now) important consequences of global warming. Therefore, when the average world temperature rises, rainfall becomes more unpredictable, and groundwater levels drop, agricultural output inevitably declines. By 2020, 2040, and 2080, it is predicted that climatic change will have a substantial effect on agricultural productivity if adaptive techniques were not adopted. Kenya's tea industry is a prime illustration of the perilous effects of climate change. It must work toward adaptation concerning crop choice and adjustments in agricultural operations in light of the most urgent dangers and concerns modelled by weather adjustment. Because climate change & its associated difficulties were so complex and ever-evolving, focused academic investigation is essential. Thus, further in-depth research into the complex interaction among climate change impacts alongside varying environmental factors, ways to irrigation, regional factors, and deviations in crop types, and the combined effects of each of these variables on agricultural output and the water cycle, is necessary.

Maritime transport is more vulnerable to climate-related concerns, especially since higher seas directly endanger the operation of ports. In addition, changes in weather patterns may impact the long-term viability of crucial maritime terminals and routes. An exemplary example is the Panama Canal, which enables around six per cent of global marine commerce. Its dependence on the accessibility of groundwater for operating reasons renders it very susceptible to variations in weather and times of droughts. In a given month, nearly one thousand ships traverse the Panama Canal, carrying over forty million pounds of commodities. That accounts for around five per cent of the entire world marine commerce flows. Nevertheless, as a result of the longest period of drought during the canal's 143 the year existence, the quantities of water in this vital route between the Pacific and Atlantic seas were

reduced to perilous depths. Moreover, the increasing elevation of the sea makes specific ports unreachable, requiring significant expenditures in infrastructures for adjustment. On the other hand, it might reveal hitherto inaccessible pathways for large cargo vessels, which could possibly change the worldwide trade system and have substantial monetary repercussions (Anadi, 2024).

Sahya et al., (2021) in their article, the study titled "Climate change effects on Aquaculture Production: Sustainability Implications, Mitigation, and Adaptations" has been released on the website Google Scholar. According to the authors, the aquaculture sector is rapidly increasing its productivity and is now the most rapidly expanding sector in world food supply. Nevertheless, the industry's viability may be in jeopardy as a result of the anticipated impacts of global warming, which aren't just a possibility but additionally a present fact. The study examines the possible impacts of global warming on seafood output and the resulting consequences for the future viability of the industry. The discussion has focused on many aspects of the changing climate, including temperature rises, higher sea levels, the spread of illnesses and toxic algae blooms, shifts in patterns of precipitation, the unpredictability of outside factors, changes in seafloor saltiness, and the occurrence of catastrophic climatic events. In addition, many strategies for adaptability were proposed, along with identified areas of insufficient understanding requiring future research. In general, climate change is projected to have a positive and negative effect on the long-term viability of seafood output. However, the adverse consequences are more significant than the favorable ones. Adjusting to the anticipated fluctuations in the near future while implementing permanent steps to reduce the impact might be the sole way to ensure the continued productivity of the industry. However, the effectiveness of adaption will be contingent upon the adaptable ability of providers in various regions around the globe.

Regan, Kim, and Maiden (2019, pp. 113-123) estimated that worldwide food yields have been cut by as much as 10% due to climate-driven catastrophic weather events. It simulated the connection between climate change-induced extreme weather events and agricultural output from 1995 to 2010 by using indicators of adaptation ability. It believed that this is the first attempt to systematically take into consideration agricultural outcomes while also taking into account the capacity of societies to adapt to changing climates. It used panel data models to determine that agricultural losses due to climatic disasters were mitigated over the national level if a country's adaptation capacity is high. In practice, the agricultural repercussions of climate change depend on the degree of diversity present between nations. Many countries have vastly various levels of structural readiness and adaptability because of different policy decisions. Predict the purpose of predicting agricultural yields in the face of escalating climatic change, it extrapolated the findings to various levels of adaptation ability.

Elliott et al., (2014, pp. 3239-3244) compared the water demand as well as supply forecasts from 10 worldwide hydrological projections and 6 worldwide “gridded crop models”. These were generated as portion of the "Inter-Sectoral Impacts Model Intercomparison Project", by oversight after the "Agricultural Model Intercomparison and Improvement Project” and, were motivated through results from “general circulation models” that were run under a good representation attentiveness trail “8.5” as portion of the "Fifth Coupled Model Intercomparison Project". “Losses of 400-1,400 Pcal (8-24% of present-day total)” were predicted for maize, soybean, wheat, as well as rice due to direct climatic impacts if the effects of CO_2 fertilization were considered, and “losses of 1,400-2,600 Pcal (24-43%)” if they were not. By the end of the century, there may be a “net loss of 600-2,900 Pcal of agricultural production” due to the deterioration of “20-60 Mha” of farmland from moistened to rainfall-fed administration due to freshwater limits in some irrigated countries “(including the western United States, China, and West, South, as well as Central Asia)”. “Northern and Eastern United

States, some of South America, much of Europe, and Southeast Asia" all have excess water supplies that could in theory sustain net increases in irrigation if the necessary irrigation infrastructure investments were made.

Kumar and Gautam (2014, pp.1-3) recommended that water, the most essential resource for life on Earth, will be significantly altered by climatic change. Human well-being and standard of life were suffering as a result of alterations to the biosphere, biodiversity, and natural resources. India is expected to warm at a faster rate than the rest of the world over the 21st century. Temperatures in India will start to fluctuate more widely throughout the year, with the winters becoming milder than the summers. With greater night temperatures as well as hotter days, the duration of heat waves in India has increased in recent years, and this tendency is predicted to continue. If CO2 levels were to double, the average global temperature would rise by 2.33°C to 4.78°C, according to projections. The agricultural industry in India will be severely impacted by the increasing unpredictability of summer rainfall during the monsoons that would be caused by these hot waves. Global warming is expected to occur gradually as "carbon dioxide (CO2)" concentrations increase, and temperatures rise, as predicted by climate models. However, these models were not particularly good at forecasting how the local climate will evolve in the future. When combined with locally suited plant types, cropping patterns, and soil conditions, local meteorological factors like rain, temperature, sunlight, and wind can enhance the production of food as long as diseases that affect plants can be managed.

Enete (2014, p. 234) decided that climate change posed a substantial danger to national security because of its effect on natural resources, ecosystems, and biodiversity. Additionally, it may cause food insecurity, people migration, economic and social malaise, and environmental and political catastrophe, all of which might have a negative impact on national growth. Primary data gathered by the "Enugu State Agricultural Development Programme

(ENADP)" on productivity over the course of four decades was utilized to analyse the influence of climatic shift on agriculture output in Enugu state. In addition, thirty years' worth of data on precipitation was obtained from the "Nigeria Meteorological Agency" (1981-2010), which was used to calculate a seasonality index and a dependability index. Descriptive statistics and a correlation analysis have been performed on the data. In addition, literature was located for examination by conducting a thorough search utilizing both electronic and non-electronic resources. Relevant articles and papers were systematically searched through the use of a variety of keywords associated with the impacts of climatic change on agriculture. Across the board, the analysis found a shift in the seasonal pattern of rainfall. The state's rainfall pattern is very cyclical, with a protracted dry season, and its reliability of rainfall is characterized by a greater degree of unpredictability in the months of highest rainfall. These shifts were visible evidence of the effects of global warming. All traditional crops except cassava along with pepper had a substantial field drop when rainfall became more irregular, the study found.

Ju et al., (2013, pp. 313-324) asserted that there were potential benefits and drawbacks to China's agricultural sector from climate change, but that the drawbacks were likely to predominate. An increase of 0.5-0.8 °C in yearly mean surface temperatures has been observed. Although both the intensity and frequency of extreme weather/climate events, notably drought, have risen during the previous 100 years in China, no discernible expansions in drizzle have been detected. Changes in the typical weather have affected agro-environmental factors such as the availability of water, the frequency and extent of insect and disease epidemics, and the quality of the soil. However, because of climate change, growing seasons have been extended in Northeast China and cold damage has been mitigated. According to climatic change projections, by the end of the 21st century, China may anticipate a further rise in surface temperature of 3.9 to 6.0 °C and an increase in precipitation of 9 to 11%. As a outcome of augmented heat produced via weather variation, the current borderline of the "triple-cropping

system (TCS)" moved north by up to "200 to 300 km", after the "Yangtze River Valley to the Yellow River Basin", and the present "double-cropping system (DCS)" shifted toward the "central part of China", hooked on the existing "single cropping system (SCS)" zone, resulting in a "decrease in SCS surface area of 23.1% by 2050." Heating temperatures have furthermore altered which regions of China were most suited to growing the country's most important crops.

2.1.4 Review related to the sea level rise on the erosion and accretion all along the coastal zone.

Nguyen et al., (2020) emphasized the vital role that coastal ecosystems play in the lives of its human beneficiaries. The downside is that these benefits have led to a rise in popularity, especially in recent centuries. Human influence has had far-reaching ramifications for coastal ecosystems and, by extension, for the security and well-being of those who live there; these effects have been exacerbated by global warming. Toan effort to produce awareness of the worldwide scope of the problem, the current study uses statistical information as well as unpublished studies to investigate two specific impacts: erosion and accretion. In addition, potential answers were investigated. The data show that accretion as well as erosion occurred in all three nations, and that their severity is increasing. The research indicated there is an immediate need to respond; the phenomenon must be halted first with technological interventions, but a thoughtful strategy will be required in the longer term, notably through constraints aimed at halting the "derogatory planning." Last but certainly not least, preserving these delicate ecosystems within natural reserves is a viable option.

Jiménez et al., (2017, pp. 593-603) addressed the fact that the Catalan coast, like the rest of the industrialized Mediterranean coastal zone, is characterized by the concurrence of stressors and strains on the natural environment with high exposure and little adaptation capacity. As a result, it is important to evaluate the consequences of natural hazards for effective long-term management because light of the fact that climate change is expected to amplify

natural hazard occurrences and their related repercussions. In this study, it evaluated three different future scenarios for Catalonia's coast, each of which includes a different amount of "sea-level rise (SLR)"—from 0.53 meters to 1.75 meters by 2100. The implications were explored in terms of the beach's two primary functions—protection and leisure. The results obtained demonstrate that CC poses a significant danger to the functions that were investigated since the anticipated heightened coastal retreat would drastically reduce the recreational capacity for carrying and, the capacity for safeguarding in the not-too-distant future under-investigated scenarios. Due to the current level of development in the coastal zone, beaches' natural resistive ability to SLR has decreased, making the shortage of accommodation space a major component in the predicted consequences.

Pramanik et al., (2016, pp.1635-1655) "discussed the low-lying tidal mudflats, sandy beaches, mangrove swamps, creeks, and tidal channels all mentioned about the 525.15-kilometer-long coastline that makes up the Krishna-Godavari coastal area on the east coast of India. In recent years, it has become increasingly important to assess the vulnerability of coastal areas to inundation alongside flooding, especially in the face of climate change-induced rise in sea levels, due to the increasing incidence of tropical hurricanes in the Bay of Bengal, such as Phylin and Hudhud in the Andhra Pradesh coastline, and the catastrophic consequences of the tsunami of 2004 in India. The purpose of this research is to establish a "coastal vulnerability index (CVI)" for the coastal subregion of the Krishna-Godavari delta and then use it to assess the susceptibility of 14 coastal talukas in this area. This CVI is determined by analyzing a variety of conventional and remotely sensed data, as well as four geological and three physical variables characterizing the vulnerability of the study coastal region. These parameters were the "regional slope, coastal elevation, geomorphology, significant wave height, mean tidal range, and relative sea level". Every one of these 14 coastal talukas received a vulnerability classification based on their relative risk rating for the aforementioned characteristics, which

formed the basis of a composite vulnerability assessment index. Where geological factors were more responsive to CVI, inundation, floods, and degradation of coastal areas were shown to be least likely and respectively, by the CVI results."

Azevedo de Almeida and Mostafavi (2016, p. 1115) established that extensive low-lying regions in many heavily populated coastal regions were in increased danger of severe storms and floods owing to excessive precipitation as a consequence of sea level rise. These events may be possible that these events will have devastating effects on coastal towns, leading to the breakdown of vital infrastructure, the suspension of economic activity, and the pollution of drinking water supplies with salt water. This study presented the findings of research conducted with the intent of identifying the various effects of rising sea levels on construction projects in coastal regions and analysing the adaptation solutions indicated in the available literature. To this purpose, a comprehensive literature search was done to compile a database of research on the effects of rising sea levels and strategies for adapting to them in the framework of current infrastructure. Water and sewage systems, power grids, and highways were the primary research areas. The data was then sorted and analysed to reveal the various implications of rising sea levels and the accompanying adaptation strategies. There were three main takeaways from the research: (1) the broad types of damage that rising seas may do to distinct types of infrastructure; (2) how to defend against, adapt to, and retreat from those damages; and (3) the difficulties that come with putting those solutions into practice.

Mahapatra, Ramakrishnan and Rajawat (2015, pp. 241-256) stated that coastal management authorities have the important job of determining how well-equipped the coast is for future sea level rise. This involves determining how susceptible the coast now is. Researchers in this study used "Remote Sensing and GIS techniques" to determine how susceptible the Gujarat coast is toward the influences of weather shift brought on by an expected rise in sea levels. Satellite remote sensing, computer models, and field observations

have been used synergistically to provide themed coastline information, which has then been validated. On a scale of 1:50,000, five physical factors were used to evaluate the coast of Gujarat for its sensitivity to flooding and erosion. This includes the major wave height, the mean springtime tidal range, the coastline slope, and the pace of shoreline development. A "Coastal Vulnerability Index (CVI)" is calculated by adding up the ranks of all five physical factors, with different sections of the coast being given different rankings depending on their vulnerability. For the coast of Gujarat, the CVI values provide four distinct categories of threat. As a result of predicted sea level rise, the outcomes suggest that “785 km (45.67%) of Gujarat's” coastline falls into the "high to very high risk" category, while 934 km (54.33%) falls into the "moderate to low risk" group. The Kachchh coast's western and northernmost sections, as well as the northernmost sections of the "Gulf of Khambhat", were in the extremely high-risk category.

Brammer (2014, pp. 51-62) determined that the coastal region of Bangladesh has a more dynamic and varied physical topography. As a result of ignoring this fact, many have formed false assumptions about how much of an influence global warming would have on sea levels in Bangladesh. Inaccurate reports on the rates of recent erosion of the coast and land subsidence have made the issue worse. Using data collected on the ground, this study details the current state of the various physiographic zones that make up Bangladesh's coastline and discusses potential regional adaptation strategies for dealing with the expected rates of rising sea levels in the twenty-first century. Two major takeaways emerge from this analysis: first, the effects of a slowly rising sea level were at present much less than the ones generated by rapidly growing pressures of population on Bangladesh's available water and land resources and by contact with existing environmental hazards; and second, the implementation of suitable solutions according to understanding of the geographical makeup of potentially-affected areas could substantially reduce the currently-predicted displacements of many millions of people.

Leorri et al., (2013, pp. 3-13) utilized geochemical and microfaunal recommendations and ancient Information for managing land, the authors of this study interpreted short cores of sediment collected after (i) “a freshly renewed salt marshes (Plentzia estuary)”, (ii) “an incipient marsh”, and (iii) “a clean marsh (Urdaibai estuary)” for proof of ecological effects and sea-level change. If the present projections of relative sea-level rise come to fruition, it is possible that the salt marsh ecosystems would become unable to adapt to rising sea levels, eventually drowning when the marsh vegetation takes the place of woody plant species in a transgressional pattern. Changes from high marsh to low marsh would occur as a result of more frequent flooding caused by a rise in sea level. This has significant ramifications for coastal management since it will eventually hint toward the formation of a mud level if maritime levels rise ahead of small marshland deposition proportions. However, data from the earth sciences show that the southeast Bay of Biscay is an exception to the rule. Reclaimed regions rapidly rise because of extremely high sedimentation rates, and within a few decades, salt marsh vegetation has colonized the area. In this case, pristine salt marshes were keeping awake with present maritime-flat rise, and extra particularly, owed to elevated “sedimentation rates”, smooth previous “intertidal mud flats have grown in rise over the last 50 years, permitting salt marsh greenery to colonize new areas.”

Williams (2013, pp.184-196) addressed how, as a result of global climate change, the threat posed to humanity and metropolitan places in coastal areas across the world by sea-level rise is growing in importance. The geological record reveals that sea level has varied over geologic time due to prior natural climatic conditions, rising as much as 6-8 meters above contemporary levels during the final interglacial warm era and falling as much as 130 meters below modern levels during the period of last glaciation. Between the years 3,000 and around the middle of the 19th century, the sea level stayed constant. Sea levels started rising at an average worldwide pace of 1.7 mm/yr throughout the 20th century. There has been a 50%

increase in the average annual rate of ascent, from 1.6 mm/yr to the present 3.1 mm/yr. Local geological (e.g., Louisiana, Chesapeake Bay), as well as oceanic (e.g., Mid-Atlantic coast) influences, as well as oceanic (e.g., Mid-Atlantic coast) influences were causing even faster rates of increase in several areas. Land uplift causes slower growth in a few places than the rest of the earth. Expanding sea levels owing to ice sheet melting & steric expansion were only two of the numerous environmental changes that may be attributed to the increase in emissions of carbon since the Industrial Revolution. Accelerating sea-level rise, with significant regional variability, is likely to persist for millennia unless measures were taken to decrease atmospheric carbon.

Storbjörk and Hedrén (2011, pp. 265-273) "analysed the sea level rise, coastal erosion, and storm surges were all predicted to worsen over the next century for coastal communities throughout the world. Meanwhile, political pressure for waterfront planning and the growth of coastal regions threatens to enhance the social vulnerability, calling for climate change mitigation in coastal area management. Assuring stronger adaptability to both present-day climatic variability and future changes in climate through the institutional component has been suggested as an essential strategy. A Swedish case research on local management of coastal areas is used to illustrate the varied and complicated nature of organizational capacity-building and to draw lessons on institutional obstacles for climate adaptation. The purpose of this study is to use case-study examples from Coast by to highlight crucial aspects that, from an institutional viewpoint, constrain the potential to accomplish a more integrated, strategic, and initiative-taking climate adaptation. As it followed and expanded upon a framework for analyzing institutional capacity-building, it learned that while a select few major players were playing a critical role in developing a strong exterior networking capacity, the other side was a weak internal organizing capacity and a lack of mutual ownership over coast erosion between sectoral units like risk-management, planning, and the environment. When it comes to

addressing coastal erosion, it discovered a lack of official, consistent policies, processes, and legislation at the municipal, regional, and national levels."

2.1.5 Review related to the corrective actions for the potential climate change hazards to maritime industries.

Kechagias et al., (2022, p. 100526) considered the digital alteration of the marine sector and that all facets of shipping operations will eventually benefit from the use of information system solutions. The marine business has a long history of dealing with safety and security concerns on a global scale, making it a highly regulated and compliant field. As it has become apparent that cyber systems were crucial to marine safety and security, cybersecurity requirements for implementation have begun to be included in the maritime regulatory environment. This study was dedicated to maritime cybersecurity, providing an insider's perspective on relevant maritime cybersecurity issues and a thorough case study analysis of a real-world company's strategy. Thus, the study's primary goal is to bridge the gap between theory and application by detailing the comprehensive approach to cybersecurity used by a maritime firm, complete with references to relevant rules and procedures. The results of The actual case investigation, together with the audit inspection of the cyber security of the vessel reveal that the firm has evaluated its existing state, gathered evidence, and objectively determined security weaknesses, all of which have led to the successful mitigation of cyber threats. The learned information will be put to use in the future to help the company's systems reach a more advanced, predictive, and initiative-taking level of development.

Abbass et al., (2022, pp.42539-42559) determined that the change in the climate is a long-term shift in global weather patterns. It is a global problem that is begun to affect many areas. The study aims to analyse and investigate the impact of climatic uncertainty on the sustainable future of many sectors worldwide. Particularly alarming is the fragility of the agricultural sector, since insufficient productivity and food supplies were at risk owing to

unpredictable weather patterns. As a result, it poses a threat to worldwide manufacturing of food, particularly in countries where agricultural plays a crucial role in economic growth and overall yield. Because many species' optimal temperature ranges have shifted as a result of global warming, the ongoing alteration of ecosystem architecture is hastening biodiversity loss. The ongoing COVID-19 pandemic serves as an illustration of the way that global warming might potentially increase the likelihood of some diseases that are transmitted by water, food, and vectors. Resistance to antimicrobial agents poses a significant threat to human wellness due to the increase of infectious illnesses that are immune to treatment. Global warming is exacerbating the rate in which this problem arises. Moreover, the global tourism sector is being severely impacted by the effects of climate change on less-than-desirable tourist destinations. The technique delves into what-if scenarios regarding weather modification variability and aims to provide visitors about a clear understanding of the facts, enabling them to discuss the issue with a thoughtful and analytical manner. Concerns about the sustainability of the environment, society, and the economy can be uncovered with the use of secondary data.

Cavanagh et al., (2021, p.615214) concluded that the "Southern Ocean" provides globally significant ecological services. Human activities (such as tourism, fishing, & research) and climate change will have long-term implications on the need for and ability to provide these services. It reviewed previous evaluations of the current state and anticipated future changes in Southern marine ecosystems due to climate change, and it analyzed the possible ramifications of these modifications for the supply of ecosystem services. It examined in depth the physical drivers, biological implications, and human advantages of climate change, all the while focusing on three essential services ("the 'blue carbon' pathway, the Antarctic krill fishery, and Antarctic tourism"). The discussion addressed the main international and regional laws regulations that can be utilized to mitigate dangers associated with the provision of these necessities in a context of climate change. Additionally, geographic policy buildings that can

be employed to address dangers to the availability of those amenities in a developing the environment were also examined. The debate also touched upon non-climatic factors that could potentially impact these amenities, including the current and future requirements for these essential services, and the impacts of climate change on these services. To fully capture the intricacy of the interplay between the many possible drivers and the numerous services, it also provided a formal model of this network of interactions. Support effective management responses in the future, it will be necessary to give more attention to the connections and feedback among drivers and ecosystem services.

Apostolou (2021) contended that the advent of cyber technology is influencing every aspect of modern life and that the shipping sector is no exception. Previously isolated vessels now have digital "smart" technologies that enable them to grow more linked both internally and to the external world. This has opened up new possibilities for the shipping sector. The reliance on cyber technologies, however, introduces additional dangers. Due to the rise in digitization of marine equipment, cyber security has emerged as a major issue for the maritime sector. Cyber hazards increasingly extend to digital-physical marine systems that affect the real world if attacked, and the threat environment is continually expanding, making maritime firms, boats, and ports vulnerable targets. The challenge for maritime regulators, shipowners, and managers is to acknowledge the gravity of cyber hazards and their potential consequences, the significance of information security, and the necessity of making it a top priority by enacting effective and resilient measures to protect shipping. This research sheds light on the state of cybersecurity in the maritime industry, provides an example of how an organization manages cybersecurity and contributes to the growing body of information on how to keep shipping safe from growing cyber threats.

C. Izaguirre, I.J. Losada, P. Camus, (2020) in their section, A study on the vulnerability of worldwide maritime activities to warming temperatures has been released by Scholar by

Google. The writers assert that the maritime industry plays a crucial role in international trade and commerce. Climate change might potentially undermine maritime operations, leading to a rise in operating interruptions and accompanying financial losses. In this study, the authors analyze the past decades of global dangers associated with the activities of 2,013 terminals internationally. They specifically focus on the implications of a luxurious heating situation, taking into account meteorological and maritime dangers, industry-established operating limits, contact, and susceptibility. The primary factors that contribute to greater danger are the escalation of storm surges and cresting caused by rising sea levels, together with the adverse effects of rising temps on thermal stress. By the year 2100, terminals in "the Hawaiian Islands, the Caribbean Sea, and Indian Ocean are projected to face an exceptionally high level of danger." On the other hand, ports in "the African Mediterranean and the Arabian Peninsula (Persian Gulf and Red Sea)" are anticipated to encounter an exceptionally high degree of risk. While it doesn't seem possible to accurately assess specific specifics at individual sites, the estimation of hazards on a worldwide level serves as a reference point for future investigation and decisions that are made.

Astrup, Wahlstrøm and King (2015, p. D031S010R015) determined that one of the most difficult tasks confronting the marine sector is preventing accidents and keeping crew members safe. A widespread misconception has led to an emphasis on workplace incidents to decrease lost time injuries, with the assumption that this will also reduce the number of serious accidents. A comprehension of the distinctions between occupational risk and major accident risk is necessary to tackle the complexity of major accident prevention and mitigation. Keeping everyone safe requires constant monitoring as the complexity of systems and activities grows. An all-encompassing safety strategy that builds strong barriers to avoid or lessen the severity of accidents is what the industry needs, not a patchwork of isolated measures. The oil and gas business has been around for a while, so they know how to manage complicated operations and

big accident threats, and offshore boats have a far lower rate of incidents than regular commercial ships. The marine industry lacks a standardized framework for dealing with large accident threats, and adopting barrier management practices from the oil and gas sector might offer such a framework.

Trathan et al., (2015, pp. 31-41) considered the whole human influence on the waters. Therefore, it looked at penguins (Spheniscidae) as a "single model taxonomic group" to investigate the potential decrease or extinction of marine organisms and communities in the southern hemisphere. The goal was to identify the most pressing dangers facing penguins today and offer solutions to these problems. Other taxonomic groupings within the southern hemisphere including northern regions, where human effects were larger, can benefit from the review. It based the analysis on the findings of 49 experts in the field, who collectively studied all 18 penguin species. It analyzed each penguin species' historical distribution, population growth/decline, and major human-caused risks during the past 250 years. “Harvesting youngsters for oil, skin, and feathers, as well as bait for crabs and rock lobster fisheries, harvesting eggs, degradation of terrestrial habitat, marine pollution, fisheries bycatch and rivalry for resource variability in the environment and climate change, and toxic algal intoxication and disease, were all factors that threatened these species.” Humans continue to pose the greatest threat to penguins due to their careless actions in destroying habitat, polluting the environment, and overfishing. Addressing present risks to existing degradation of habitat on land and in the sea will very definitely determine their future resistance to further consequences of climate change. It argued that protecting penguin breeding grounds, in tandem with the creation of suitably sized marine reserves around the globe, including the High Seas, is essential to the species' long-term survival.

Anthony et al., (2015, pp. 48-61) reported that the linked impacts of weather adjustment, ocean acidification, and other global, regional, and regional stressors provide

significant difficulties for coral reef managers across the world. Successful reef conservation requires an understanding of how sensitivity to several stressors accumulates over time. In this synthesis, it argued that coral reef vulnerability (the risk of net loss) may be lowered by purposeful management of improved ecological resiliency (capacity for resistance to stress and recovery). In particular, it suggested an operational methodology for locating efficient management levers to improve resilience and back up decisions made by management to lessen reef vulnerability. The study proposed an "Adaptive Resilience-Based Management (ARBM)" paradigm and provided a set of suggestions for improving resiliency via managerial initiatives, based on a system understanding of the "biological and ecological processes that drive resilience of coral reefs in different environmental and socio-economic settings. It argued that pulse-type (acute) stressors (e.g., storms, bleaching events, crown-of-thorns starfish outbreaks) increase the demand for resilience while press-type (chronic) stressors (e.g., pollution, sedimentation, overfishing, ocean warming, and acidification) pose a key threat to coral reef resilience by affecting processes underpinning resistance and recovery." Several challenges involving reefs in the Caribbean and the Indo-Pacific were used to illustrate the framework's use. Important objectives for managing the ecological system of a reef are to comprehend the events that occur within the ecology and evaluating the impact of outside influences and socioeconomic causes should create a plan that actively reduces risk while also bolstering resilience.

Ziervogel et al., (2014, pp. 605-620) assessed the state-of-the-art and most recent findings in climate change impact and adaptation studies in South Africa. The change in the climate scenarios established regarding the southern African area is supported by South Africa's robust earth system scientific research program. While climate change scenarios have been integrated into existing investigation of the environmental consequences of warming temperatures on essential industries like fluid, the agricultural sector, and wildlife., further

study is needed in several other subjects, incorporating the impacts of warming temperatures on urban areas and the construction sector. A "National Climate Change Response White Paper" has been drafted by the federal government, but this has not still not a translation of this concept throughout an approach that effectively incorporates adaptability into daily activities and forecasting of every industry and tier of administration. There is now a national effort under progress investigating potential adjustments over the course of several years possibilities, with a particular emphasis on the interconnectedness of various sectors in national adaptation responses. There were signs of adaptation reactions appearing in certain areas. Despite the implementation of several impressive city-scale and project-based adaption strategies, institutional difficulties continue to be a problem. Several gaps in understanding the socioeconomic and biophysical effects of climate change still exist. The ability to conduct comprehensive assessments of the changing climate is particularly important for building climate-resilient infrastructure in South Africa.

Patrick Schmitt, Marcin Lukasz Bartosiak, Torbjorn Rydbergh (2020) in their article, Spatiotemporal Data Analytics for the Maritime Industry. According to the writers, timely access to precise data is crucial for generating profit within any company, including the marine sector. Analysis of data plays a crucial role in the shipping industry by enhancing shipping routes, improving the efficiency of ports, minimizing contamination, and contributing to environmental conservation. By leveraging the continuous flow of digital information from widespread instruments and transmitting devices, it becomes feasible to monitor the location of nearly anything in both time and space. This capability enhances sense of situation and ultimately enhances the effectiveness of maritime missions. "Spatiotemporal data" combines together spatially and time-based components, making it very valuable in the marine domain but also posing analytic challenges. In the next section, the contributors discuss the current status of "spatiotemporal analytics" and offer a description of how it can be used in the marine

sector. The situations outlined include for a long-time scheduling, environmental conservation, incident prevention, cargo monitoring, and minimization of port calls.

Moreira (2014) addressed how, despite a shift in focus in recent years, there is still a paucity of scholarly works on the issue from a global perspective. Nonetheless, academics on a national level were not producing any literature on the environmental and social sustainability in the maritime sector, even though the fact that this topic is important for a variety of reasons and touches on both the maritime network alongside the supply chain administration that is based on global assumptions. Nonetheless, based on the basis of active citizenship as well as pooled sources of social value, both private and public policymakers, and organizations were beginning to prioritize sustainability in all of its forms. There is a whole sector that, while being crucial to the global economy and for the well-being of the people, continued to be controlled in a way that necessitates no more regulation than their actual application, even as worry about climate change rises and the instances of marine catastrophes multiply. A vital sector of the economy for the future, but also a major source of pollutants and several types of both air and marine contamination, and one that must eventually stop treating the world's oceans and seas as a sewage system. Therefore, it opted to start from the beginning to extract the foundations, which involved extensive work in gathering and analyzing institutional information and unrolling the complex network that this issue, which affects the whole marine sector, comprises.

2.2 Research Gap

There has been a lot of progress made in the study of "Climate change's consequences for the marine industry" in the past few decades, with an increasingly large amount of literature addressing issues such as increasing rising sea levels, the acidification of the oceans, and extreme weather conditions. However, there is a noticeable void in the understanding of the

combinatorial and cascading consequences of these many climate change factors on the maritime sector as a whole. Utmost investigation focuses on one effect at a time, ignoring the cumulative and long-term effects. More research is required to fully understand the social, economic, and regulatory ramifications of climate change's effects on the maritime sector, particularly as they pertain to the loss of employment and income, the decline in the quality of life for communities along the coast, and the disruption of the international supply chain of goods. In addition, the study typically doesn't include a prospective viewpoint on potential climate change mitigation and adaptation solutions, which hinders the creation of proactive regulations and procedures for protecting this vital industry in an environment of an increasingly unpredictable climatic future. For the sake of directing sustainable growth and resilience-building activities in the maritime sector and tackling the critical global problem of climate change, filling this research vacuum is crucial.

Chapter III:

METHODOLOGY

3.1. Overview

Research methodology is an in-depth justification of how the study is carried out. The methods for collecting information and the criteria for evaluating sources are described in depth. The procedure and strategies used to collect data and develop conclusions approaching a selected issue are detected as “Research Methodology”. A study's methodology outlines the techniques employed to obtain data that supports the study's assertions. It is a systematic and logical approach to study. A research technique describes how a researcher conducts their study to provide authentic, dependable data that fulfills their goals.

“Climate change” has complicated and broad ramifications for the maritime sector, endangering ecosystems, coastal infrastructure, and marine operations. Marine biodiversity is changing, migratory patterns are shifting, and severe weather events are becoming more often and intense as a result of ocean warming, which is a result of increasing global temperatures. Shipping routes, port operations, and vessel safety are all impacted by these developments, which provide substantial problems for the marine industry. Ports, shipyards, and offshore sites are just some of the coastal facilities and infrastructure that might be at risk from rising sea levels. Marine businesses must adjust to the changing climate by adopting sustainable methods that reduce the impact on the environment and make their operations more resistant to the outcomes of weather transformation.

The chapter gives a concise summary of the research methods that were used to gather the data as well as the multiple tests so that the obtained data could be used to empirically analyse the hypotheses that were developed based on the investigation's goals, a bibliographic analysis was conducted. The current chapter contains a description of the methods and techniques that the researcher utilized to carry out the specified study task. It provides

information in great depth regarding the sample design, research design, source of data, and analytical methods that were utilized in the study.

3.2 Operational Term

3.2.1 Operational Term

i. Climate Change

"Climate change" describes the overall trend of altered climate models and average temperatures over a long period. Variations in solar activity or large-scale volcanic eruptions might be to blame for these shifts. However, "burning fossil fuels like oil, gas, and coal has been the primary" human-caused contributor to climate change since the 1800s (Kumar et al., 2021).

ii. Marine Industry

Seafood and ocean products are used as raw materials by marine-based companies, which include those that process seafood and produce fish oil. Marine industries are those that employ sea and ocean products as raw materials (Suleria et al., 2015).

iii. Erosion

Soil, rock, or substances that dissolve is carried from one location on the Earth's crust to another by surface activities such as wind or water movement; this process is called erosion. Since weathering does not include movement, it differs from erosion. When rock or soil is washed away as clastic debris, it is known as physical or mechanical erosion. When soil or rock is broken down, it is referred to as chemical erosion (Lussi & Jaeggi, 2008).

iv. Coastal Zone

Coastal ecosystems are especially vulnerable to the rapid degradation that may appear as an effect of unchecked sub-urbanization and infrastructural expansion, as well as disorderly industrial, tourist, fishing, and agricultural pursuits (Keith, 2020).

v. Agricultural Output

The ratio of agricultural inputs to outputs is the standard measure of agricultural productivity. The variability of goods makes it challenging to estimate agricultural production as a whole, in contrast to the conventional practice of assessing individual items by weight (crop yield). A common metric for agricultural productivity is the end product's market value (Reardon, & Timmer, 2007).

3.2.2 Impact on sea transportation

The retreating of mountains contributes to the increase in sea levels, which in turn impacts the flow of water. This alteration also leads to changes in the climate. However, changes in the sea floor may also be seen positively since they create new pathways for the transportation and growth of invasive plants and animals. Vessels of considerable size may be easily accepted, and some canals located in the interior may be reopened after the level of water receded. Weather fluctuations may lead to the occurrence of floods, as well as the accumulation of waste and sediment in narrow and weak waterways. This accumulation can result in the closure of these passages and need repairs to ships. These variables may impact the movement of goods from a single spot to others (Cavanagh et al., 2021).

- **Impact on ports and infrastructure**

The majority of coastal structures, such as ports, containers, and connections, must be modified in response to the increasing rising waves, tropical storms, and storms which result

in severe interruptions and destruction. Many harbors worldwide have experienced significant vulnerability and severe damage as a result of cyclones and disasters.

- **Response to the impact**

Government worldwide is increasingly adopting international power regulations aimed at reducing reliance on petroleum and coal, conserving assets and enhancing economy via decreased waste and increased recycling. The logistics business has responded positively to these initiatives.

- **Response from the international shipping**

"The International Maritime Organization (IMO)" reached a consensus to reduce greenhouse gases and mandate an enhancement in shipping economy in the near future. Maritime corporations additionally announced a commitment to decrease the environmental impact of new ships. The transport industry is now facing new challenges, including the implementation of regulations to reduce sulfur emissions and the need for studies on renewable energy sources to replace petroleum and diesel.

The effects of climate change are evident in the thawing of Antarctic ice caps, resulting in elevated ocean levels, the expansion of habitable arid areas, and the occurrence of greater severity meteorological and physical phenomena, such as intensified cyclones and hurricanes occurring more often. Transportation drivers are perhaps most highly conscious of the impact of global warming among all sectors. They are experiencing the consequences of erratic weather, extreme hurricanes, disrupted shipping routes, and ecological transformations. These factors significantly impact their operations, necessitating adjustments or even abandonment of standard company procedures and transportation routes. Logistics corporations are not only greatly affected by the effects of global warming, though they also play a significant role in

causing it. In 2016, transport accounted for twenty-eight percent of GHGs emissions in the US. Additionally, more than half of cars globally continue to rely on gasoline made from petroleum, which is one of the primary contributors to sulfur dioxide emissions (Cavanagh et al., 2021).

3.2.3 The main adverse effects of climate change on maritime transport

- **Re – routing becomes more common**

As to the findings of "the World Maritime University (manaadiar, 2020)," the ongoing melting of glaciers in the North Pole caused by increasing temperatures is resulting in the rise of waves, an exacerbation of storm surges, and alteration of sedimentary processes. This substantial alteration had a considerable influence on shipping lanes.

Consequently, due to the diminished safety and convenience of current paths, there is necessary to devise alternative paths. Route modifications may create significant inconvenience and hinder production for consumers and transportation firms. Rather than executing their usual activities, shipping businesses must allocate time as well as money to strategize alternatives. The consumer will be impacted by the longer travel time, which will impair their delivery.

- **Increased risk of port infrastructure damage**

Colin Gannon, a senior analyst with an environmental risk mitigation organization, wrote an essay highlighting the danger that rising sea levels poses to maritime facilities. Naturally, due to evident factors, the port's facilities is going to be swamped and rendered inoperable. That is important to acknowledge that the rise in sea levels is characterized by a consistent and gradual pace, but its capacity for causing destruction is inevitable.

In a 2011 poll, numerous harbors showed a lack of optimism over the safety associated with their equipment. They said that the objectives are based upon a 10 year perspective,

despite the fact that most equipment is constructed to be durable over several generations. In order to address this issue, modifications in construction and construction methodologies are under way. However, at now, it won't be possible to completely remove the risk of destroying infrastructure.

- **Lower productivity**

The blend of rising sea levels, hurricanes, and floods will have a deleterious impact on terrestrial security. Furthermore, the impacts will extend beyond the port facilities. The functioning of several terminals could be considerably impacted by the flooding resulting from storms and hurricanes. To be further precise, workers will become unable to operate during periods of interruptions, resulting in a loss of probable revenue. Moreover, the prolongation and escalated expenses associated with the maintenance, rehabilitation, or maybe even transfer of certain buildings might have an additional impact on revenue (Kum Fai Yuen, 2017).

- **Additional operating cost**

As previously said, unforeseen expenses are necessary for the upkeep or relocation of infrastructure in the aftermath of a hurricane wave. Nevertheless, the expenditures continue to occur at that point. Due to the rise in temperatures, there is a possibility of an associated rise in cooling expenses. Moreover, adverse circumstances such as lengthy instances of storms might result in longer journeys and less economically efficient paths for shipping. Furthermore, instances of excessive precipitation may cause significant disruptions to crucial maritime operations, including the handling and transfer of goods, both during their arrival at and departure from terminals (Elyakim Ben-Hakoun, 2020).

- **Decreased demand for services**

As a result of dryness and increased heat, the process of cultivating commodities become harder than environmentally viable. Indeed, in the aforementioned research authored by Gannon, research confirmed a substantial decline in the yield of organic crops such as soybeans, flour, and maize in "Illinois is inadequate, Missouri, and other states" throughout the United States. Consequently, when the quantity of items to be transported decreases, consumer appetite for transportation businesses' services would also decrease. The earnings derived by ports might significantly decrease when the total amount of accessible firms likewise declines (manaadiar, 2020).

- **Technology and energy used improvements**

The use of technological advancements and enhancements in energy utilization has the potential to decrease pollution by substituting outdated, more fuel-efficient, or more environmentally harmful machinery and motors. The anticipated benefits of implementing technological solutions, such as advancements in hull, England, propellant, and machine technology, to decrease energy use and carbon dioxide emissions is "5-30% in new ships and 4-20%" in older vessels. Implementing a substantial transition to other engines and sources of electricity may pose challenges in the near future, since the current leading alternatives aren't yet able to completely rival diesel-powered vehicles. Under certain conditions, it may be feasible to transition between fuel such as diesel to gas from the earth. Ports, being crucial hubs in the transportation network and having the capacity to collaborate with other stakeholders, can effectively decrease both individual carbon and pollutants generated across entirety of supply chains. One way to do that is by partnering alongside additional businesses in the logistics and travel sector and jointly acquiring ground machinery and autos, such as feeders, and boats, and railroads. In July 2008, ports demonstrated their dedication to reducing carbon emissions by officially adopting "the World Ports Climate Declaration." The future development of biodiesel is unclear due to worries over their manufacturing procedures and

the potential ramifications for nutrition, the environment, and biodiversity. Their adoption will be contingent upon advancements in the realm of less contentious energy production, that today are not generally accessible. Future possibilities include "solar powered sails, hydrogen-propelled ships, and fuel cell electricity for auxiliary engines." More advances in methods for capturing and storing carbon might be used in the transportation industry (Panitchpakdi, 2009).

- **Operational Measures**

Operational strategies play a crucial role in mitigating CO2 emissions, because they possess the capacity to reduce emissions of CO2 by up to forty percent in the near term. This may be achieved by actions such as redirecting and reducing velocity. Reducing the top speed of an airplane in order to decrease fuel use and, therefore, lower GHG emissions is a crucial cost-saving tactic in the shipping sector. Decreasing speed by 10 percent might result in a twenty-five percent decrease in fuel usage. Several transportation companies have used this technique to reduce their operational expenses amid the significant increase in petroleum and diesel costs in 2008. Manufacturers have lowered the pace at which ships travel, evaluated the timing of their paths, and formed alliances and partnerships in order to benefit from cost advantages by combining current shipping paths and using bigger, cleaner-burning boats. These cuts in expenses have had the additional benefit of a bit mitigating the increase in shipping expenses, which may have had a detrimental impact on commerce, especially that of emerging nations. Within ports, enhancing activities may include actions such as restructuring facilities to optimize barges accessibility, boosting on-dock transportation capacities, expediting the unloading and loading processes, minimizing traffic jams, and providing shore-side energy (Panitchpakdi, 2009) .

Currently, the subject of GHGs is a widespread environmental concern on a worldwide scale. According to specialists, the issue may be resolved by widely implementing the steps

that follow: Shifts in renewable energy employ. Decrease in the percentage and amount of biomass (including methane peat moss charcoal) and petroleum. Adopting petroleum as an energy source would substantially decrease the amount of carbon dioxide (CO2) released into the atmosphere. Expanding the proportion of renewable energies such as solar, wind, and hydro power would lead to a decrease in emissions, since these technologies enable the generation of power with minimal harm to the ecosystem. No hazardous gasses are emitted while utilizing them. Enhanced efficiency in operation of generating facilities. Decrease in the electrical efficiency of goods at industrial facilities. Development of energy-efficient technology. The standard insulation of buildings' exteriors, windows, and boilers yields a substantial outcome by reducing pollutants. To address the issue at the company, commercial, and national levels, a comprehensive worldwide enhancement of the circumstances is necessary. Any person has the ability to contributes towards resolving this issue by engaging with energy conservation, adopting proper disposal practices, and implementing evaluates for heating their homes efficiently. Additionally, technological advancements that focus on producing goods in ecologically sustainable ways can be pursued. Utilizing recycled materials is another successful strategy to minimize waste generation while minimizing the need for dumps. Furthermore, efforts to revitalize woodlands, combat burning forests, and expand forested areas can help decrease the overall level of the greenhouse gases in the environment. Currently, the battle against GHGs is being waged on a global scale. International conferences have been convened to address this issue, with the objective of formulating comprehensive strategies to tackle this issue. A multitude of academics worldwide are actively involved in the pursuit of methods to mitigate the warming climate, hence preserving the equilibrium and sustenance that exists on Planet. Developing strategies to mitigate the GHGs impact is very advantageous. In both "the United Kingdom and the United States," teams of researchers have successfully developed an apparatus consisting of energetic compounds that break down GHGs and convert them into

beneficial particles. During that time period, there existed a lack of sufficiently advanced technology capable of isolating these atoms in their unbound state (Mikhaylov et al., 2020).

3.3 Importance of the Study

Addressing the complex issues brought on by environmental changes requires a thorough understanding of how climate change is affecting the maritime industry. The maritime sector confronts never-before-seen difficulties, from changes in fisheries patterns to the amplification of severe weather events, as a result of rising temperatures worldwide, melting ice caps, and changes in ocean currents. To build resilient infrastructure, sustainable resource management practices, and adaptive methods, it is essential to comprehend the intricate relationships “between climate change and the marine environment.” The condition of the seas directly affects the marine sector, which is a crucial part of the world economy. The study helps to ensure that marine ecosystems, biodiversity, and the means of subsistence for countless communities dependent on marine resources remain viable in the long run by conducting an in-depth analysis of how climate change is affecting this industry.

3.4 Conceptual Framework

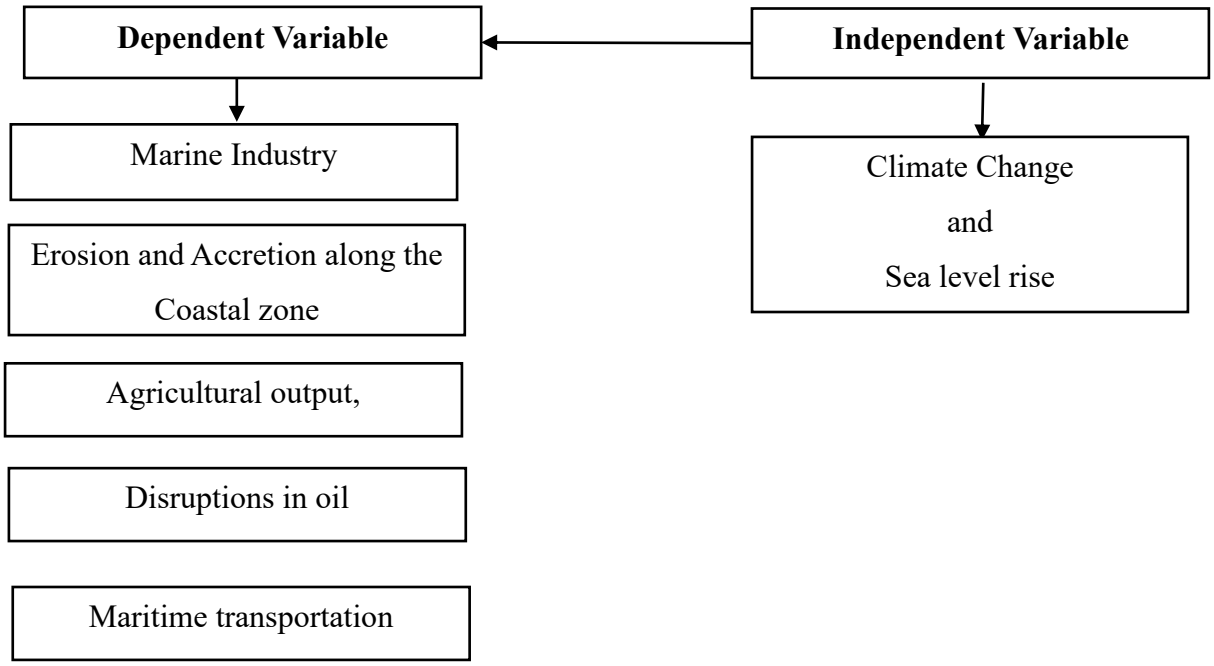


Figure 3.1: Conceptual Framework

3.5 Variables of the Study

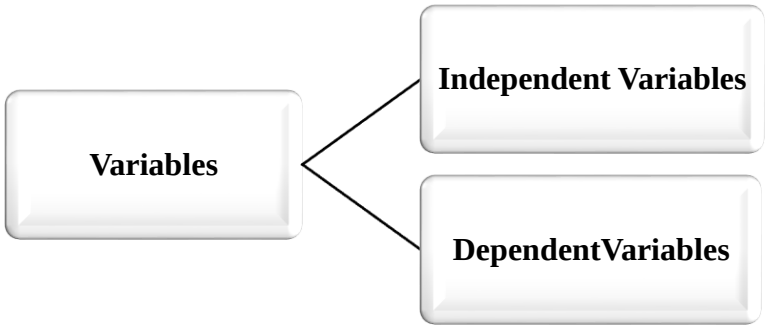


Figure 3.2: Variables

In statistics and research, variables are items that can be changed, managed, or measured. Every study looks at a distinct variable. The variable can be "someone, place, thing, or idea." Over time or across categories, the value of a variable may vary. The term often

includes elements that might influence or reflect a relationship or outcome. It is divided into two categories:

3.5.1 Independent Variables

The term "independent variable" refers to a variable that may be manipulated or altered without any influence from other variables. Independent variables are the variables that researchers intentionally manipulate to examine their impact on the dependent variable. The independent variable is considered autonomous subsequently it is untouched by former considerations within the study. The “independent variables” in the study are Climate change and sea level rise.

3.5.2 Dependent Variables

A dependent variable is a variable that is influenced, either fully or partly, by the “contribution or antecedent variable. Changes to the independent variables' numbers cause commensurate” changes to the dependent variables' values. The parameter under study, known as the dependent variable, is subject to change as a result of adjustments applied to the independent variables. The “dependent variables” are the Maritime industry, Erosion, and accretion along the coastal zone, Agricultural output, Disruptions in oil transportation, and Maritime transportation.

3.6 Objectives of the Study

- To determine how climate change affects the maritime industry.
- To determine how erosion and accretion all along the coastal zone are impacted by sea level rise.
- To look into how climate change affects agricultural output and how that affects marine transportation.

- To examine how climate change affects oil transportation and how it affects maritime transportation in turn.
- To find out the reasons behind climate change.
- To determine the corrective actions for the potential climate change hazards to maritime industries.

3.7 Hypothesis of the Study

H0a: “There is no significant impact of climate change on the maritime industry”.

H1a: “There is a significant impact of climate change on the maritime industry”.

H0b: “There is no significant impact of sea level rise on erosion and accretion along the coastal zone”.

H1b: “There is a significant impact of sea level rise on erosion and accretion along the coastal zone”.

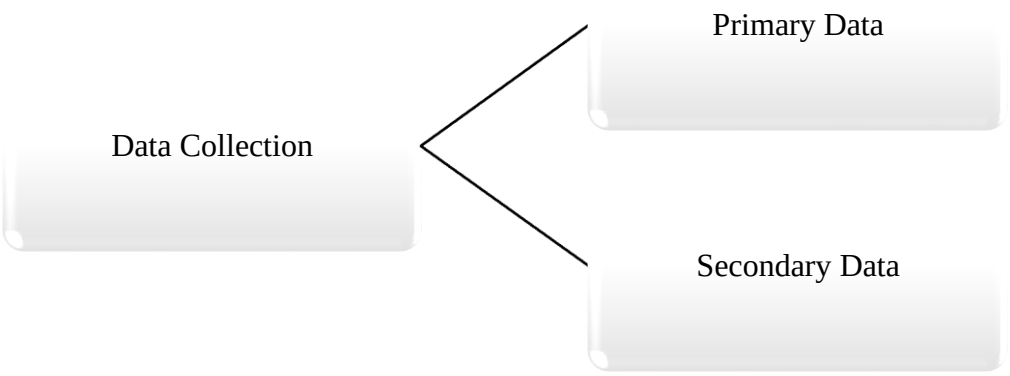
H0c: “There is no significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation”.

H1c: “There is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation”.

H0d: “There is no significant relationship between climate change and disruptions in oil transportation, which subsequently affect marine transportation”.

H1d: “There is a significant relationship between climate change and disruptions in oil transportation, which subsequently affect maritime transportation”.

3.8 “Data Collection”



“Figure 3.3: Collection of Data”

Primary Data: “Primary data” is defined as information that is gathered initially and directly from its source for a specific research purpose. Observations, surveys, experiments, interviews, and direct encounters with study participants are some of the techniques used by researchers to gather primary data. Primary data is collected through a “means of a questionnaire that was designed keeping in mind all the variables that were to be tested.

Secondary Data: Any information or statistics that researchers have previously gathered from sources are referred to as secondary data. Secondary research might be either quantitative or qualitative. It typically uses data from public and commercial databases and datasets, meta-analyses, or peer-reviewed articles. “Secondary data” is collected from “books, journals, and articles from various websites, reports, magazines, newspapers, documents, periodicals, and circulars”.

- In the study, both “Primary data” and “Secondary data” are employed.

3.9 Area of the Study

The study area of the study is “India". A study on the effects of climate change on the maritime sector would benefit substantially from a focus on India due to the country's extensive coastline, diverse marine ecosystems, and rapidly expanding maritime industry, all of which are essential to international trade and commerce. As the nation is becoming more exposed to climate change, as shown by signs like increasing frequency of severe weather events, shifting ocean temperatures, and rising sea levels, it is crucial to comprehend and handle the ramifications for the marine sector. Examining the Indian context can help formulate area-specific plans and strategies for weather change variation and mitigation within the larger global framework, in addition to providing insightful information on the unique issues encountered by the marine industry in this region.

3.10 Universe of the Study

The study's main goal is to investigate how climate change is affecting India's maritime sector, paying particular attention to four important population groups: coastguards, merchants, sailors, and fishers. These stakeholders are essential to the marine industry, and learning from their views and experiences is going to be vital to comprehend the complex effects of climate change. Through interviews with those directly engaged in fishing, trading, navigation, and coastal security, the research seeks to provide a thorough portrayal of the maritime sector. The study provides a detailed knowledge of the difficulties and adjustments that the marine community as a whole must make in response to the changing climatic circumstances by concentrating on these varied groupings.

3.11 Research Design

A mixed-methods strategy was used in the study, which included combining both qualitative and quantitative methods. The quantitative component entails gathering and

evaluating pertinent statistical data, such as measures of sea level rise, historical temperature patterns, and the frequency of severe weather events that have an impact on Indian waterways. In parallel, a qualitative component has been included through surveys and interviews with important stakeholders, including representatives of the government, business leaders, and ecologists. These qualitative techniques provide complex insights into the attitudes, difficulties, and coping mechanisms of the maritime sector. Through the integration of quantitative and qualitative data, the study seeks to provide a comprehensive understanding of the multi-faceted effects of global warming on the Indian marine industry.

3.12 Sampling Design

The study used the Stratified Random Sampling method. The study has targeted the population of fishermen, merchants, sailors, as well as coastguards. From this, a sample can be determined using Cochran's (1977) formula for calculating sample size and stratified random sampling method. The sample size is determined as:

Stratified random sampling method.

$$n = \frac{z^2}{4e^2}$$

$$n = \frac{(1.96)^2}{4(0.05)^2} = 384.16$$

$n =$ "Sample size"

$e =$ "Acceptable sampling error (e = 0.05)"

$z =$ "z value at reliability level or significance level"

"Reliability level 95% or significance level 0.05; z = 1.96"

With the help of the “stratified random sampling method,” the respondents are divided into subcategories called strata which are based on characteristics they share. The subcategory has been divided as per age group to find the sample for the study.

The study used a sample size of “95% confidence level and a 5% margin of error”. Data has been collected from 384 respondents through scales, and finally, data from 300 respondents, who have completed the questionaries in complete manner, has been considered for the study. “Random sampling technique” is used for choosing the respondents from the target population. “The final sample size for the study is 300 respondents.”

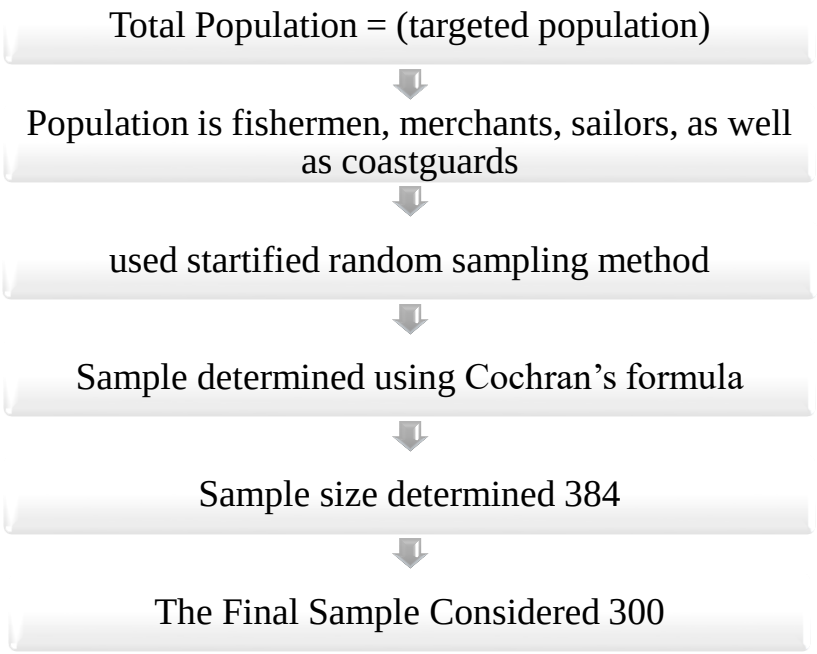


Figure 3.4: Sample Process

3.13 Statistical Tools

"Statistical tools" that are employed in the study are as follows:

a. SPSS

SPSS, or "Statistical Package for the Social Sciences," is a tool that allows users to access and alter data stored in external relational databases. SPSS is widely employed by researchers "for in-depth statistical analysis." SPSS was created primarily for quantitatively organizing and analyzing social science data. SPSS is a graphical platform for constructing more sophisticated models.

b. MS Excel

Microsoft Excel is a popular statistics application for studying statistical concepts and calculating to validate hand-worked computations while dealing with professional concerns. This tool may be used to store and evaluate numerical data. Excel is a spreadsheet software included in "Microsoft's Office suite". To "format, organize, and compute" spreadsheet data, Microsoft Excel can be utilized. The data is simple to enter, read, and manipulate.

3.14 Statistical Techniques

The study makes use of the following statistical techniques:

a) Arithmetic Mean

The Arithmetic Mean is calculated by performing the operation of division the total of all elements in a given set by the group's size. As a statistical measure of central tendency, the "arithmetic mean" is the most frequently utilized. The meaning of a set of numbers is the average of those numbers. The "arithmetic mean is preferred" over the "geometric mean" and "harmonic mean".

$$m = \frac{\textbf{Sum of the terms}}{\textbf{number of terms}}$$

b) Standard deviation

The standard deviation determines the degree to which data differs from the mean. When the "standard deviation" is low, data clusters around the mean; when it is large, data disperses. It is widely used since it keeps the original measuring units for data collection. The "standard deviation," sometimes known as the "square root of the variance," is a measure of departure from the mean.

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

c) Correlation

Correlation is a statistical connection between two or more variables. It assesses the extent to which variations in one variable are linked with variations in another. Nevertheless, correlation does not indicate causation; the fact that two variables are connected does not suggest that one causes the other to change. Correlation is a valuable tool in various fields, including psychology, economics, and science, as it helps researchers identify patterns and make predictions based on observed data.

$$r = \frac{\Sigma(x_i - \overline{x})\,(y_i - \overline{y})}{\sqrt{\Sigma(x_i - \overline{x})^2 \Sigma(y_i - \overline{y})^2}}$$

d) Regression

The statistical technique of regression may be used to establish a link between two variables and the effects they have on one another. The formula establishes the connection between two factors. Predicting future trends and occurrences is a common use of this method.

$$Y_i = f(X_i, \beta) + e_i$$

Y_i = "Dependent Variable"

f = "Function"

X_i = "Independent Variable"

β = "Unknown Parameters"

e_i = "Error Terms"

3.15 Conclusion

This study's approach offered a thorough and organized framework for studying how climate change is affecting the marine sector. The study gathered extensive data from multiple sources and viewpoints by adopting a mixed-methodologies technique, which combines quantitative and qualitative methods. Surveys and interviews with marine industry stakeholders provided rich primary data on their perspectives, feelings, and experiences with climate change. Furthermore, a more comprehensive grasp of the topic was achieved by utilizing secondary data derived from literature studies and current research.

By employing statistical methods including regression analysis and correlation testing, the study's hypotheses were rigorously examined. The results corroborated the predictions, showing that weather alteration will take a foremost consequence proceeding to the marine sector, on agricultural production, on oil transportation disruptions impacting maritime transportation, on coastal erosion and accretion caused by rising sea levels, and on agricultural output generally. These findings highlighted the need to address issues caused by climate change and put strong safeguards in place for the marine industry.

In sum, the analytical methodologies, data gathering procedure, and research methodology created a solid groundwork for comprehending the intricate interplay between

climate change and the marine sector. Policymakers, industry stakeholders, and researchers tackling the climate change concerns in the marine sector can benefit from the study's practical implications, which are based on the identification of important factors, objectives, and hypotheses.

Chapter IV:

RESULTS

4.1 Overview

The first section starts by presenting the fundamental components that assess the influence of global warming on the shipping sector. Prior to conducting a comprehensive analysis, the section starts by delineating the important elements that influence these relationships. Demographics assessment enables a comprehensive description of those involved and offers significant historical data. This chapter employs stringent dependability checks to ensure the precision and credibility of the gathered data. Assessing the dependability and uniformity of the study's results is essential in order to establish its trustworthiness. Moreover, reference methodologies are employed to enhance efficiency and enhance precision by simplifying the evaluation procedure. The findings obtained from the proposed theories provided fantastic insight into the issues of the research, since they were well described. The replies provided by those surveyed were meticulously examined, resulting in a comprehensive understanding of their perspectives. The chapter empirically analyses the impact of the climate change on marine industry. To give a comprehensive picture of the major variables to analyse the impact of the climate change on marine industry, used meticulous utilization of information evaluation and presentation.

➢ Hypothesis for Respondents

H0a: “There is no significant impact of climate change on the maritime industry”.

H1a: “There is a significant impact of climate change on the maritime industry”.

H0b: “There is no significant impact of sea level rise on erosion and accretion along the coastal zone”.

H1b: “There is a significant impact of sea level rise on erosion and accretion along the coastal zone”.

H0c: “There is no significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation”.

H1c: “There is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation”.

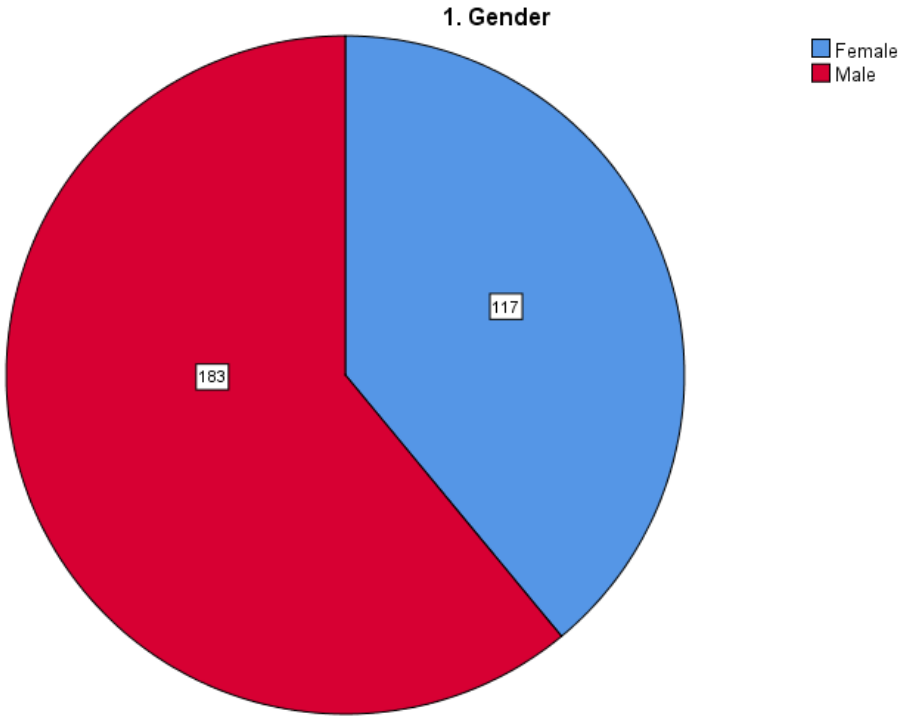
H0d: “There is no significant relationship between climate change and disruptions in oil transportation, which subsequently affect marine transportation”.

H1d: “There is a significant relationship between climate change and disruptions in oil transportation, which subsequently affect maritime transportation”.

4.2 “Demographic Profile of Employees”

Table 4.1 Gender of Respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	117	39.0	39.0	39.0
	Male	183	61.0	61.0	100.0
	Total	300	100.0	100.0	



"Figure 4.1: Gender of the Respondents"

The graph labelled four and the pie diagram, also referred to as figure 4.1, provide information on the age group of those who responded. The table below shows the fact that three hundred people chosen for the research, 184 are men, making up 61.00% of the entire the sample, while 118 are females, accounting for 39.00% of the entire population.

Table 4.2 Age of Respondents

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-34	141	47.0	47.0	47.0
	35-54	74	24.7	24.7	71.7

	55 or over	27	9.0	9.0	80.7
	Less than 18	58	19.3	19.3	100.0
	Total	300	100.0	100.0	

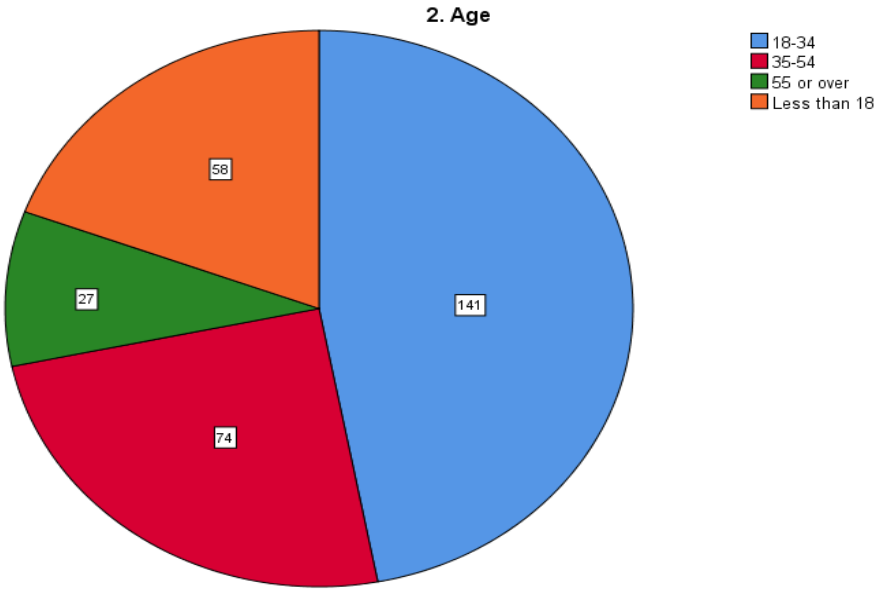


Figure 4.2: Age of the respondents

"The above table 4.2 and pie chart (figure 4.2) define the age group of the respondents. According to table 4.2, it is observed that, out of the 300 respondents selected for the study, 47.00 % of the respondents are in the age group of 18 - 34 years, 24.70 % of the respondents fall in the age group of 35 - 54 years, 9.00 % of the respondents are above 55 years and 19.30 % of the respondents are below 18 years. The age group is between 18 - 34 years with the highest (47.00 %) of the sample respondents."

Table 4.3 Education level of Respondents

Education Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor's Degree	80	26.7	26.7	26.7
	High School or equivalent	99	33.0	33.0	59.7
	Master's Degree or higher	69	23.0	23.0	82.7
	Other:	52	17.3	17.3	100.0
	Total	300	100.0	100.0	

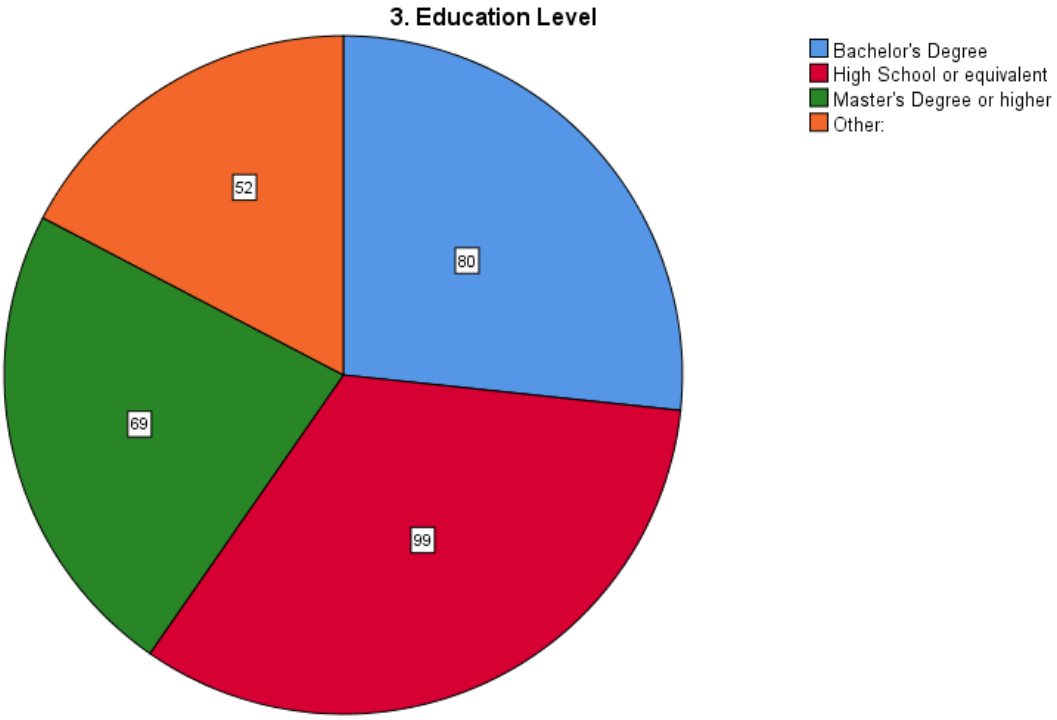


Figure 4.3: Education Level of the Respondents

"The above Table 4.3 and pie chart (figure 4.3) define the education level of the respondents." It is observed from Table 4.3 that out of 300 respondents, 26.70 % of the respondents are bachelor's degree holders, 33.00 % of the respondents are high school degree holders or equivalent, 23.00 % of the respondents are master's degree holders, and the remaining 17.30 % of the respondents are from other qualification. It is understood that the majority of the respondents are high school degree holders or equivalent (33.00 %).

Table 4.4 Occupation within the marine industry

Occupation within the marine industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Coastal Engineer	71	23.7	23.7	23.7

	Fisherman/Fisherwoman	110	36.7	36.7	60.3
	Marine Technician	80	26.7	26.7	87.0
	Other:	39	13.0	13.0	100.0
	Total	300	100.0	100.0	

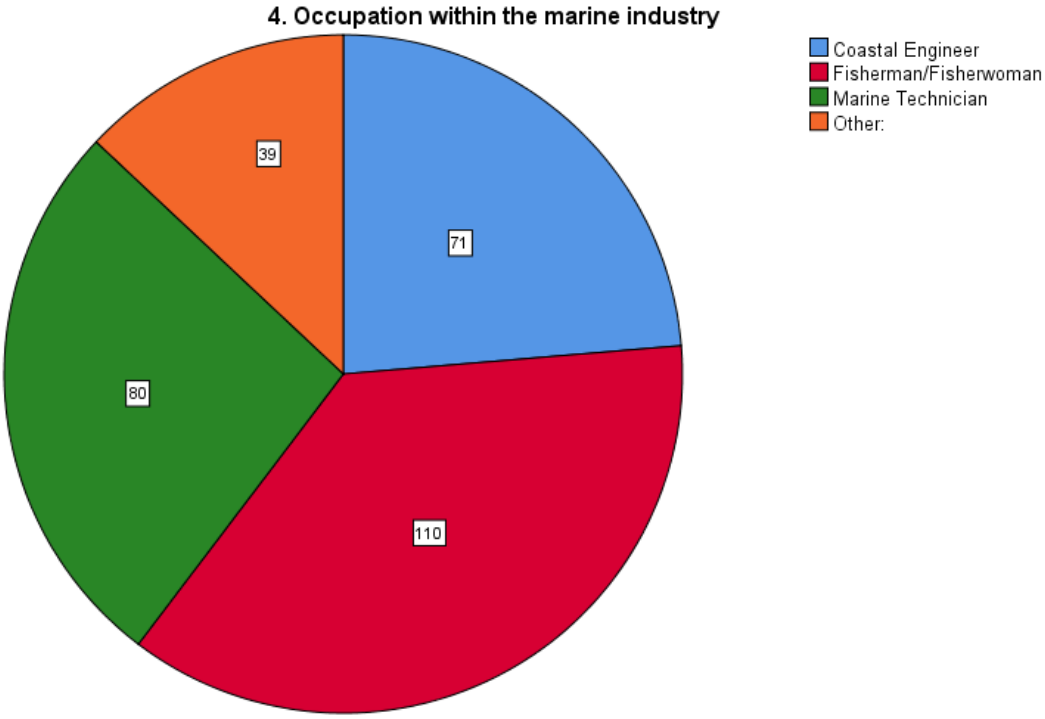


Figure 4.4 Occupation within the marine industry

"The above Table 4.4 and pie chart (figure 4.4) define" the Occupations within the marine industry of the respondents. It is observed from Table 4.4 that out of 300 respondents, 23.70 % of the respondents are Coastal Engineer, 36.70 % of the respondents are Fisherman/Fisherwoman, 26.70 % of the respondents are Marine Technician, and the

remaining 13.00 % of the respondents are from other occupations. It is understood that the majority of the respondents are Fisherman/Fisherwoman (36.70 %).

Table 4.5 Years of experience in the marine industry

Years of experience in the marine industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 years	68	22.7	22.7	22.7
	6-10 years	86	28.7	28.7	51.3
	Less than 1 year	83	27.7	27.7	79.0
	More than 10 years	63	21.0	21.0	100.0
	Total	300	100.0	100.0	

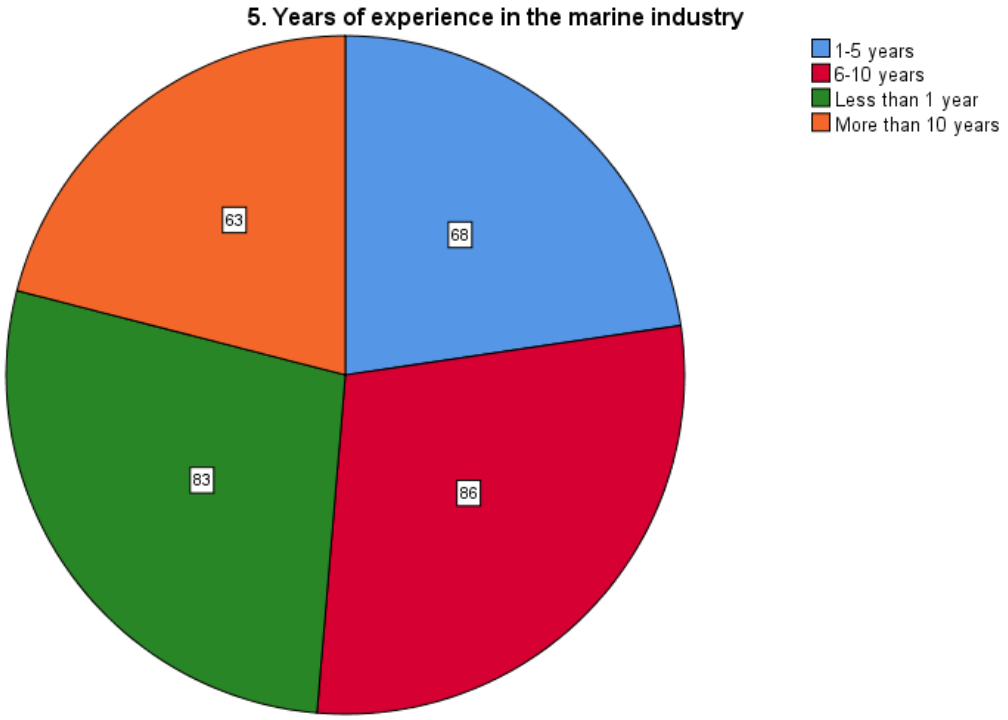


Figure 4.5 Years of experience in the marine industry

"The above Table 4.5 and pie chart (figure 4.5) define the Years of experience in the marine industry of the respondents. It is observed from Table 4.5 that out of 300 respondents, 22.70 % of the respondents have 1-5 years of experience, 28.70 % of the respondents have 6-10 years of experience, 27.70 % of the respondents have Less than 1 year of experience, and 21.00 % of the respondents have More than 10 years of experience. It is understood that the majority of the respondents have 6-10 years of experience (28.70 %)."

Table 4.6 Primary Role in the marine industry

Primary Role in the marine industry				
	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Management/Executive	98	32.7	32.7	32.7
	Operations/Fieldwork	63	21.0	21.0	53.7
	Other:	40	13.3	13.3	67.0
	Research/Science	45	15.0	15.0	82.0
	Support/Administrative	54	18.0	18.0	100.0
	Total	300	100.0	100.0	

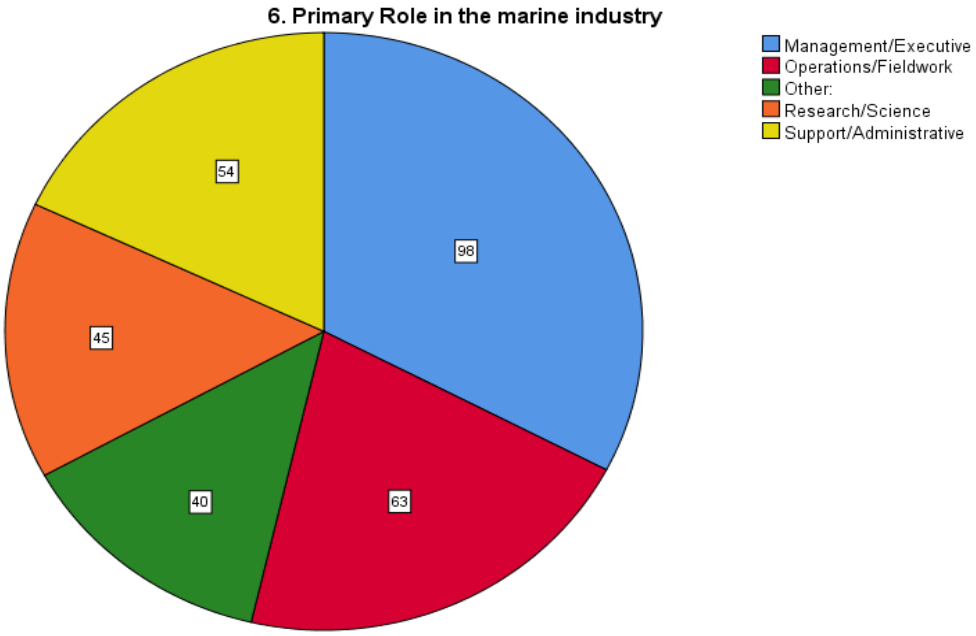


Figure 4.6 Primary Role in the marine industry

“The above Table 4.6 and pie chart (figure 4.6) define the Primary Role in the marine industry of the respondents.” It is observed from Table 4.6 that out of 300 respondents, 32.70 % of the respondents are Management/Executive, 21.00 % of the respondents are Operations/Fieldwork, 15.00 % of the respondents are Research/Science,18.00 % of the respondents are Support/Administrative and 13.30 % of the respondents are in others role. It is understood that the majority of the respondents are Management/Executive (32.70 %).

Table 4.7 Income Level

Income Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	$25,000 - $50,000	63	21.0	21.0	21.0
	$50,001 - $75,000	85	28.3	28.3	49.3
	Above $75,000	66	22.0	22.0	71.3
	Below $25,000	86	28.7	28.7	100.0
	Total	300	100.0	100.0	

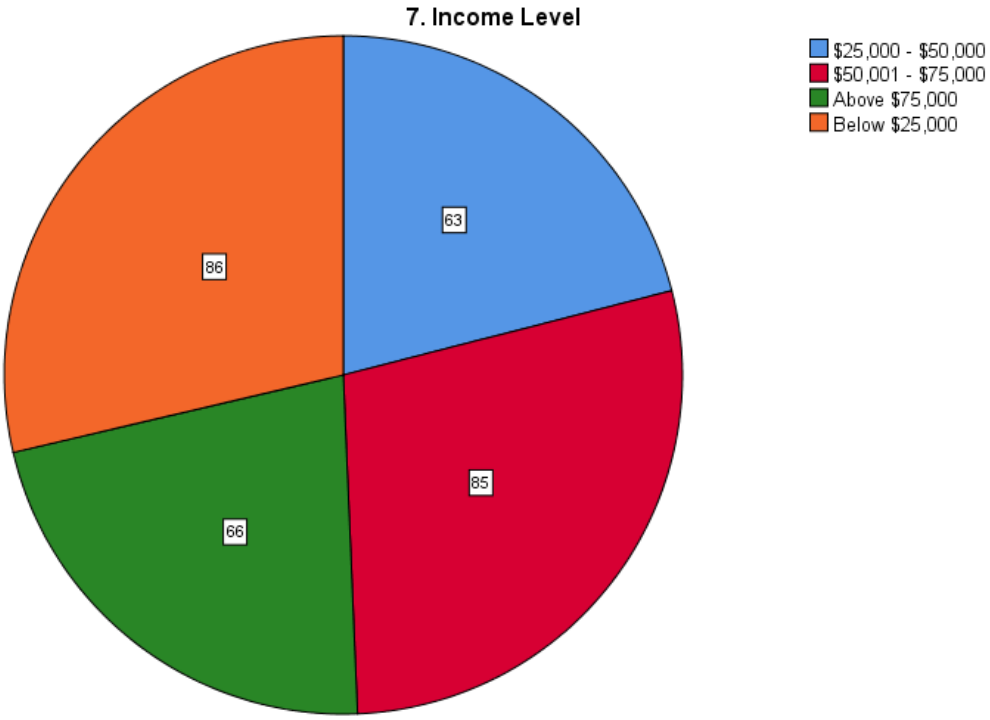


Figure 4.7 Income Level

"The above Table 4.7 and pie chart (figure 4.7) define the Income Level of the respondents. It is observed from Table 4.7 that out of 300 respondents, 21.00 % of the respondents earn between $25,000 - $50,000, 28.30 % of the respondents earn between $50,001 - $75,000, 22.00 % of the respondents earn Above $75,000, and 28.7 % of the respondents earn Below $25,000. It is understood that the majority of the respondents earn Below $25,000 (28.70 %)."

Table 4.8 Familiarity with climate change issues

Familiarity with climate change issues					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Familiar	96	32.0	32.0	32.0

	Somewhat Familiar	84	28.0	28.0	60.0
	Very Familiar	120	40.0	40.0	100.0
	Total	300	100.0	100.0	

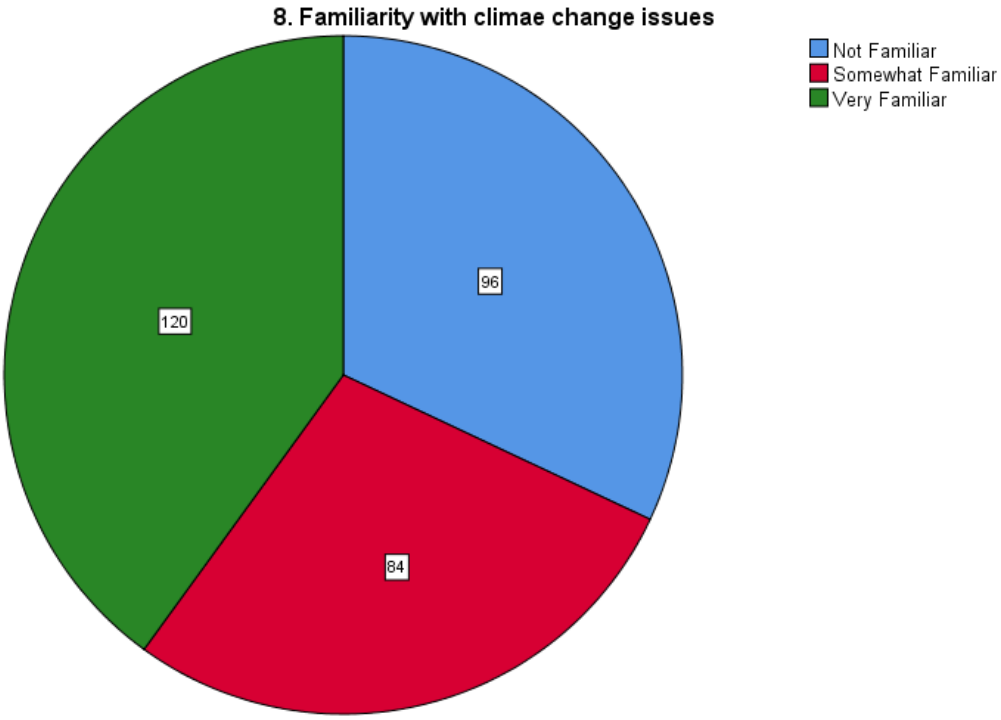


Figure 4.8 Familiarity with climate change issues

"Above Table 4.8 and pie chart (figure 4.8)" define the Familiarity with climate change issues of the respondents. It is observed from Table 4.8 that out of 300 respondents, 32.00 % of the respondents are Not Familiar, 28.00 % of the respondents are Somewhat Familiar and 40.00 % of the respondents are Very Familiar. It is unstated that the widespread of the respondents are Very Familiar (40.00 %).

Table 4.9 Perception of the threat of climate change to the marine industry

Perception of the threat of climate change to the marine industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Minor Threat	66	22.0	22.0	22.0
	Moderate Threat	59	19.7	19.7	41.7
	Not a Threat	78	26.0	26.0	67.7
	Significant Threat	97	32.3	32.3	100.0
	Total	300	100.0	100.0	

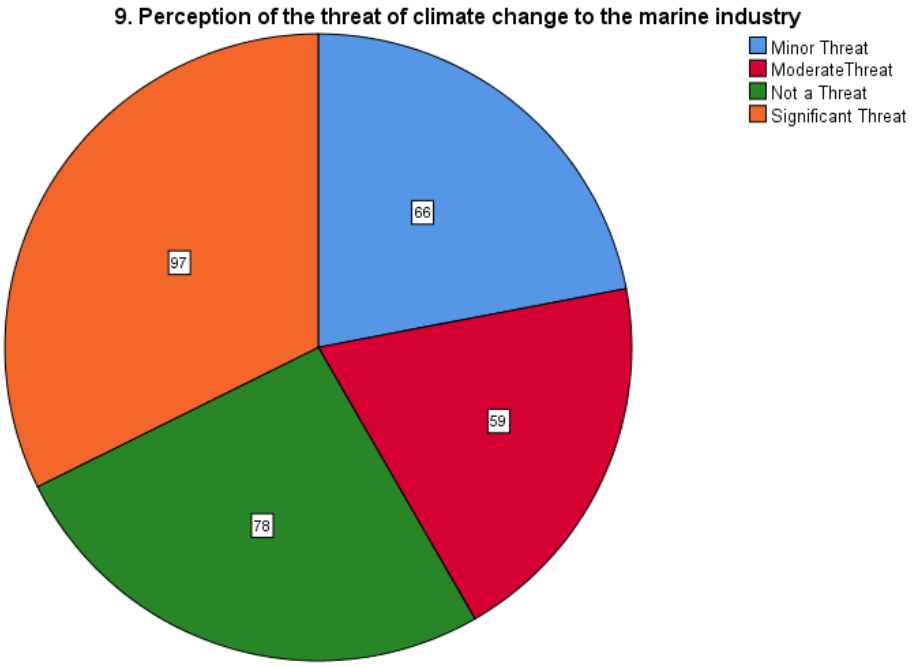


Figure 4.9 Perception of the threat of climate change to the marine industry

"The above Table 4.9 and pie chart (figure 4.9) define the Perception of the threat of climate change to the marine industry of the respondents. It is observed from Table 4.9 that out of 300 respondents, 22.00 % of the respondents felt a Minor Threat, 19.70 % of the respondents felt a Moderate Threat, 26.00 % of the respondents felt No Threat and 32.00 % of the respondents felt a Significant Threat. It is understood that the majority of the respondents felt a Significant Threat (32.30 %)."

Table 4.10 Concern about the economic impacts of climate change on the marine industry

Concern about the economic impacts of climate change on the marine industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Concerned	96	32.0	32.0	32.0
	Somewhat Concerned	168	56.0	56.0	88.0
	Very Concerned	36	12.0	12.0	100.0
	Total	300	100.0	100.0	

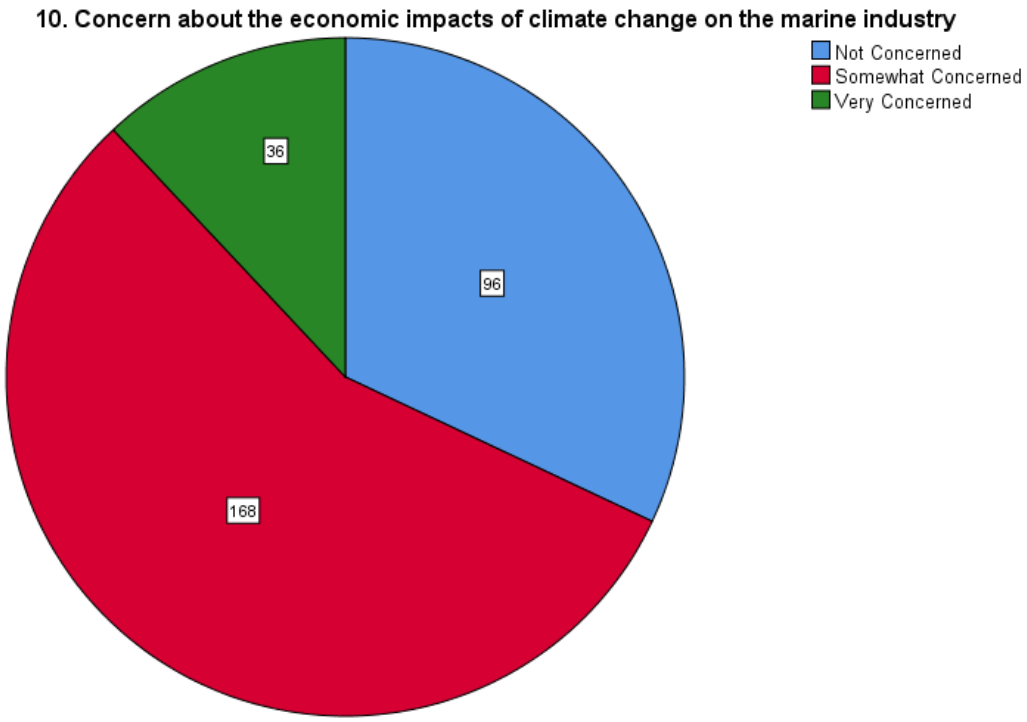


Figure 4.10 Concern about the economic impacts of climate change on the marine industry

"The above Table 4.10 and pie chart (figure 4.10) define the Concern about the economic impacts of climate change on the marine industry of the respondents. It is observed from Table 4.10 that out of 300 respondents, 32.00 % of the respondents are Not Concerned, 56.00 % of the respondents are Somewhat Concerned and 12.00 % of the respondents are Very Concerned. It is understood that the majority of the respondents are Somewhat Concerned (56.00 %)."

H0a: "There is no significant impact of climate change on the maritime industry".

H1a: "There is a significant impact of climate change on the maritime industry".

Table 4.11 Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.114[a]	.013	.010	5.46025
a. Predictors: (Constant), Climate change				

Table 4.11 provides a concise overview of the model, demonstrating a substantial level of correlation. The coefficient of determination for the Pearson correlation is 0.114, indicating the extent to which the variable in question's total variation is accounted. The maritime industry is affected by climate change. A separate variable might be used to elucidate the outcomes.

Table 4.12 ANOVA[a]

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	116.238	1	116.238	3.899	.049[b]
	Residual	8884.679	298	29.814		
	Total	9000.917	299			
a. Dependent Variable: Impact on the marine industry from climate change						

b. Predictors: (Constant), Climate change

"The table provided is the one for ANOVA 4.12, which presents the degree of fit between the model of regression and the data, specifically in terms of predicting the variable in question. This table demonstrates that the model of regression accurately predicts the variable that is dependent with a high level of significance. The model of regression has a statistical significance of 0.049, which is below the threshold of 0.05. This suggests that the regression model is a good match for the data and can predict the outcome variable with statistical significance."

Table 4.13: Coefficients[a]

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.615	1.884		10.940	.000
	Climate change	.146	.074	.114	1.975	.049
a. Dependent Variable: Impact on the marine industry from climate change						

The Coefficients Table 4.13 provides us with the necessary information to predict the effect of "Climate Change", as well as determine whether the "Impact on the marine industry from climate change" is statistically significant to the model.

H0b: "There is no significant impact of sea level rise on erosion and accretion along the coastal zone".

H1b: "There is a significant impact of sea level rise on erosion and accretion along the coastal zone".

Table 4.14: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.115[a]	.013	.010	3.70257
a. Predictors: (Constant), Sea Level Rise.				

"Table 4.14 provides a precise description of the model summary, demonstrating a substantial level of correlation. The R-value for the simple correlation is 0.115, indicating the extent to which the independent variable can account for the variation in the dependent variable, Erosion and Accretion along the Coastal Zone."

Table 4.15: ANOVA[a]

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.

1	Regression	54.751	1	54.751	3.994	.047[b]
	Residual	4085.285	298	13.709		
	Total	4140.037	299			
a. Dependent Variable: Erosion and Accretion along the Coastal Zone.						
b. Predictors: (Constant), Sea Level Rise.						

"The ANOVA table 4.15 shown above displays the degree to which the regression equation accurately fits the data and predicts the dependent variable. This table demonstrates that the regression model accurately predicts the dependent variable with a high level of statistical significance. The regression model has a statistical significance of 0.047, which is below the threshold of 0.05. This suggests that the regression model is a good match for the data and can predict the outcome variable with statistical significance."

Table 4.16: Coefficients[a]

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	24.608	.943		26.097	.000
	Sea Level Rise.	.081	.041	.115	1.998	.047

a. Dependent Variable: Erosion and Accretion along the Coastal Zone.

"The Coefficients Table 4.16 provides us with the necessary information to predict the effect of the "Sea Level Rise", as well as determine whether the "Erosion and Accretion along the Coastal Zone" is statistically significant to the model."

H0c: "There is no significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation".

H1c: "There is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation".

Table 4.17: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.120[a]	.014	.011	3.42168
a. Predictors: (Constant), Climate change				

"Table 4.17 provides the model summary, which shows a considerable level of correlation. The R-value for the simple correlation is 0.120, indicating the extent to which the independent variable can account for the variation in the dependent variable, Marine Transportation."

Table 4.18: ANOVA[a]

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.793	1	50.793	4.338	.038[b]
	Residual	3488.954	298	11.708		
	Total	3539.747	299			
a. Dependent Variable: Marine Transportation.						
b. Predictors: (Constant), Climate change						

"The table provided is ANOVA table 4.18, which presents the degree to which the regression equation accurately fits the data and predicts the dependent variable. This table demonstrates that the regression model accurately predicts the dependent variable with a high level of statistical significance. The regression model has a statistical significance of 0.038, which is below the threshold of 0.05. This implies that the regression model is a good match for the data and can predict the outcome variable with statistical significance."

Table 4.19: Coefficients[a]

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	27.338	1.181		23.151	.000

	Climate change	-.097	.046	-.120	-2.083	.038
a. Dependent Variable: Marine Transportation.						

"The Coefficients Table 4.19 provides us with the necessary information to predict the effect of "Climate change", as well as determine whether "Marine Transportation" is statistically significant to the model."

H0d: "There is no significant relationship between climate change and disruptions in oil transportation, which subsequently affect marine transportation".

H1d: "There is a significant relationship between climate change and disruptions in oil transportation, which subsequently affect maritime transportation".

Table 4.20: Descriptive statistics

Descriptive Statistics			
	Mean	Std. Deviation	N
Climate change	25.0500	4.25769	300
Oil transportation	24.5900	4.83250	300

The above table 4.20 defines the descriptive statistics of the Climate Change and Oil Transportation. The mean score of Employees' Perceptions of Human Rights Issues is 25.05 whereas the score of Employee Satisfaction is 24.59.

Table 4.21: Correlations

Correlations			
		Climate change	Oil transportation
Climate change	Pearson Correlation	1	.277**
	Sig. (2-tailed)		.000
	N	300	300
Oil transportation	Pearson Correlation	.277**	1
	Sig. (2-tailed)	.000	
	N	300	300
**. Correlation is significant at the 0.01 level (2-tailed).			

The above table 4.21 defines the correlation between Climate Change and Oil Transportation, they are statistically significantly correlated between the Employees' Perceptions of Human Rights Issues and Employee Satisfaction because the sig worth is 0.000 (i.e., the significance value is lower than 0.05)

4.3 "Summary of Findings Based on Demographic Profile"

- “The sample size of the respondents was 300 respondents. Findings identified the “gender of the respondents”. It was found that 183 were males, who constitute 61.0 % and 117 were females who form 39.0 % of the total sample respondents.”
- The findings stated the “age group of the respondents”. It was observed that, out of the 300 respondents selected for the study, 47.00 % of the respondents are in the age group of 18 - 34 years, 24.70 % of the respondents fall in the age group of 35 - 54 years, 9.00 % of the respondents are above 55 years and 19.30 % of the respondents are below 18 years. The age group is between 18 - 34 years, with the highest (47.00 %) of the sample respondents.
- The findings stated the “education level of the respondents”. It observed that out of 300 respondents, 26.70 % of the respondents are bachelor’s degree holders, 33.00 % of the respondents are high school degree holders or equivalent, 23.00 % of the respondents are master’s degree holders, and the remaining 17.30 % of the respondents are from other qualification. It is understood that the majority of the respondents are high school degree holders or equivalent (33.00 %).
- The findings stated the “years of work experience of the respondents”. It was observed from Table 4.5 that out of 300 respondents, 22.70 % of the respondents have 1-5 years of experience, 28.70 % of the respondents have 6-10 years of experience, 27.70 % of the respondents have Less than 1 year of experience, and 21.00 % of the respondents have More than 10 years of experience. It is understood that the majority of the respondents have 6-10 years of experience (28.70 %).
- “The findings stated the “Occupations within the marine industry of the respondents”. It was detected that available of 300 accused, 23.70 % of the accused are Coastal Engineer, 36.70 % of the respondents are Fisherman/Fisherwoman, 26.70 % of the respondents are Marine Technician, and the remaining 13.00 % of the respondents are from other

occupations. It is understood that the majority of the respondents are fishermen/Fisherwoman (36.70 %)."

- Findings stated the "Primary Role in the marine industry of the respondents". It was observed that out of 300 respondents, 32.70 % of the respondents are Management/Executive, 21.00 % of the respondents are Operations/Fieldwork, 15.00 % of the respondents are Research/Science,18.00 % of the respondents are Support/Administrative, and 13.30 % of the respondents are in others role. It is understood that the majority of the respondents are Management/Executive (32.70 %).
- Findings stated the "Income Level of the respondents". It was detected that ready of 300 accused, 21.00 % of the respondents earn between $25,000 - $50,000, 28.30 % of the respondents earn between $50,001 - $75,000, 22.00 % of the respondents earn Above $75,000, and 28.7 % of the respondents earn Below $25,000. It is understood that the majority of the respondents earn Below $25,000 (28.70 %).
- The findings stated the "Familiarity with climate change issues of the respondents. "It was observed that out of 300 respondents, 32.00 % of the respondents" are Not Familiar, 28.00 % of the respondents are Somewhat Familiar, and 40.00 % of the respondents are Very Familiar. It is understood that the majority of the respondents are Very Familiar (40.00 %).
- Findings stated the "Perception of the threat of climate change to the marine industry. It was observed that out of 300 respondents, 22.00 % of the respondents felt a Minor Threat, 19.70 % of the respondents felt a Moderate Threat, 26.00 % of the respondents felt No Threat, and 32.00 % of the respondents felt a Significant Threat. It is understood that the majority of the respondents felt a Significant Threat (32.30 %)."
- Findings stated the "Concern about the economic impacts of climate change on the marine industry of the respondents. It was observed that out of 300 respondents, 32.00 % of the

respondents are Not Concerned, 56.00 % of the respondents are Somewhat Concerned, and 12.00 % of the respondents are Very Concerned. It is understood that the majority of the respondents are Somewhat Concerned (56.00 %)."

4.4 Summary of findings Based on Hypothesis

H1: There is a significant impact of climate change on the maritime industry.

- **Impact of climate change on the maritime industry**

- The "regression test" was second-hand to recognize "the impact of climate change on the maritime industry."
- As per findings, the "R-value for the simple correlation was 0.114, which reflects how much of the overall variance in the dependent variable (maritime industry) can be explained by the independent variable **(**climate change)".
- According to the findings, "there was a statistical significance of the regression model 0.049, which was less than 0.05, and indicated that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it was a good fit for the data)". So, "the alternative hypothesis (H1) is accepted."

"H2: There is a significant impact of sea level rise on erosion and accretion along the coastal zone."

- The regression test was applied to recognize that there is a significant impact of sea level rise on erosion and accretion along the coastal zone.
- As per findings, the "R-value for the simple correlation was 0.115, which reflects how much of the overall variance in the dependent variable, Erosion and Accretion along the Coastal Zone, the independent variable, Sea Level rise, can be used to explain the results".

- According to the findings, “there was a statistical significance of the regression model 0.047, which was less than 0.05, and indicated that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it was a good fit for the data)”. “So, the alternative hypothesis (H2) is accepted.”

“H3: There is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation.”

- The regression test was applied to recognize that there is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation.
- As per findings, the “R-value for the simple correlation was 0.120, which reflects how much of the overall variance in the dependent variable, Marine Transportation, the independent variable, climate change, can be used to explain the results”.
- According to the findings, “there was a statistical significance of the regression model 0.038, which was less than 0.05, and indicated that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it was a good fit for the data)”. So, the alternative hypothesis (H3) is accepted.

“H4: There is a significant relationship between climate change and disruptions in oil transportation, which subsequently affect maritime transportation.”

- A “correlation test” was used to recognize the relationship between climate change and disruptions in oil transportation, which subsequently affect maritime transportation.
- According to the findings, the mean score of Respondents’ Perceptions of Climate Change was 25.05 whereas the score of Oil transportation was 37.34.
- According to the findings, there was a statistically significant correlation between climate change and disruptions in oil transportation, which subsequently affect maritime

transportation because the sig value was 0.000 (i.e., “sig value was less than 0.05”). Thus, the “alternative hypothesis (H4) is accepted”.

Table 4.22: An Overview of the Previously Stated Hypothesis and the Corresponding Results

S. No.	Objectives	Hypothesis	Statistical Technique	Results
1.	To determine how climate change affects the maritime industry.	H1: There is a significant impact of climate change on the maritime industry	Regression	H1 is Accepted
2.	To determine how erosion and accretion all along the coastal zone are impacted by sea level rise.	H2: There is a significant impact of sea level rise on erosion and accretion along the coastal zone.	Regression	H2 is Accepted
3.	To look into how climate change affects agricultural output and how that affects marine transportation.	H3: There is a significant effect of climate change on agricultural output, and, consequently, there is no impact on marine transportation.	Regression	H3 is Accepted
4.	To examine how climate change affects oil transportation and how it	H4: There is a significant relationship between climate change and disruptions in oil	Correlation	

	affects maritime transportation in turn.	transportation, which subsequently affect maritime transportation.		H4 is Accepted
5.	To find out the reasons behind climate change.	_____	_____	_____

4.5 Conclusion

Disputes stemming from botched procedures and medical malpractices were the subject of a comprehensive examination in this study, which drew on the demographic profiles of 300 participants. Important demographic details about gender, age, education, years of work experience, marine industry occupations, main roles, income, income level, familiarity with climate change issues, perception of climate change threats to the marine industry, and concerns about the economic impacts of climate change were uncovered by the findings.

The majority of the respondents were men, and their demographics were as follows: they were between the ages of 18 and 34, had a high school diploma or equivalent, had 6 to 10 years of work experience, were mainly employed in fishing, held management or executive positions, earned less than $25,000 per year, and were very knowledgeable about climate change. Not only that, but many people were worried about the maritime industry's future and the economy as a whole due to climate change. Additionally, the study examined four theories on how climate change would influence maritime transportation, how rising sea levels will affect coastal erosion, how climate change will affect agricultural production, and how

disruptions in oil delivery will impact maritime transportation. All four predictions were confirmed by the results, which show how climate change is already having a major effect on the maritime sector and the legal ramifications that follow. These findings highlight the need to tackle climate change-related issues, put appropriate safeguards in place to reduce risks, and ensure the sustainability and legal integrity of the maritime industry.

Chapter V:

DISCUSSION

5.1 Discussion of Research Question One

What effects does climate change have on the maritime sector?

Tables 4.11, 4.12, and 4.13 show evidence that supports the idea that the marine industry is feeling the effects of climate change. To gain a better understanding of how variations in biomass are linked to climate events, the concentration of phytoplankton chlorophyll-a in the Indonesian Maritime Continent was monitored using satellite data for twenty years. It was shown that phytoplankton biomass is greatly affected by climatic variations, especially the Indian Ocean Dipole (IOD) and El Niño/Southern Oscillation (ENSO) as evaluated by (Siswanto et al., 2020, p. 103451). On the other hand, (Wang et al., 2020, p. 102173) examines the duties and partnerships along the worldwide marine industry's value chain in achieving the 17 SDGs, as determined by a content analysis of sustainability reports covering the years 2016–2019. Table 4.11 displays the model summary, which shows that there is a weak correlation (R=0.114) “between climate change and its effects on the marine industry.” With a statistically significant F-value of 3.899 (p = 0.049), the regression model accurately predicts the influence of climate change on the maritime industry, according to the ANOVA results in Table 4.12. This suggests that climate change is a major explanatory variable for the observed variation in the dependent variable.

The coefficients linked to climate change are shown in Table 4.13, which provides further evidence in support of these findings. Also, (Saether, Eide and Bjørgum, 2021, pp.2382-2395) explored the connection between emissions reduction, innovation, sustainability, and long-term planning in Norwegian marine companies, implying that these elements indirectly impact emissions reductions and aid in the combat global warming. In relation to the previous

study the present study formed a favourable correlation between climate change and its effects on the maritime industry is suggested by the standardized coefficient (Beta) of 0.114. In addition, the coefficient is statistically significant (t-value = 1.975, p = 0.049), further supporting the idea that climate change significantly affects the marine industry. Taken together, the findings lend credence to the idea that the marine industry is feeling the effects of climate change. The significance of tackling climate change-related issues in the marine industry and taking proactive steps to lessen its negative impacts on marine ecosystems, infrastructure, and operations is highlighted by these results.

5.2 Discussion of Research Question Two

How does climate change affect the movement of oil, and how does it affect maritime transportation?

Tables 4.14, 4.15, and 4.16 show the data that support the theory of how erosion and accretion along the coast are affected by rising sea levels. (Boatemaa, Kwasi and Mensah, 2013, pp. 359-367) investigated sea level rise and coastal erosion's toll on Anyanui, Ghana's mangrove forests. At a pace of 2.32 meters per year, the coastal zone of Keta is being eroded, while the sea level is rising at a record-breaking rate of 3 millimetres each year. In support, the current study evaluated that an R-value of 0.115 shows a significant relationship between sea level rise and erosion/accretion along the coastal zone, according to the model summary in Table 4.14. What this means is that erosion and accretion, “the dependent variables, are partially explained by the independent variable,” sea level rise. Also, (Gornitz, 1991, pp .379-398) stated that Inundation, erosion, and salinization pose threats to coastal regions, human populations, and cities as a result of a 0.3-0.9 m increase in sea levels predicted by greenhouse gas emissions in the next century. The world's sea levels are now rising at a pace of 1-2 millimetres per year, and this rate has the potential to accelerate by three to eight times in the

next century. Although, Table 4.15's analysis of variance shows that the regression model successfully forecasts coastal erosion and accretion (F-value: 3.994, p = 0.047). This suggests that the variance in erosion and accretion is partly explained by the rise in sea levels.

Cooper, Beevers, Oppenheimer (2008, pp. 475-492) assessed the possible consequences of rising sea levels on the coastal region of New Jersey, including both chronic flooding and more frequent floods, are being predicted. It implies that coastal storms would become more frequent and that 1% to 3% of the land would be permanently submerged. Adaptation solutions should be investigated by policymakers. Contiguous to the study the present study coefficients linked to sea level rise are shown in Table 4.16, which provides more evidence for these conclusions. A positive correlation between sea level rise and erosion/accretion along the coastal zone is suggested by "the standardized coefficient (Beta) of 0.115." Furthermore, the coefficient is statistically significant (t-value = 1.998, p = 0.047), further supporting the idea that sea level rise significantly affects the dynamics of coastal erosion and accretion. Overall, the findings provide credence to the null hypothesis (H1a) that sea level rise does affect erosion and accretion in the coastal zone. In light of these results, it is critical to develop adaptation measures to lessen the impact of sea level rise on coastal ecosystems and people, as well as to solve the difficulties associated with coastal management.

5.3 Discussion of Research Question Three

How to investigate how climate change affects agricultural output and how it affects maritime transportation?

Results from Tables 4.17, 4.18, and 4.19 provide evidence for or against the idea that climate change would reduce agricultural production, which will have repercussions for maritime trade. (Koetse and Rietveld, 2009, pp. 205-221) discovered worldwide changes in tourism, agricultural output, sea levels, storm surges, flooding, infrastructure interruptions, and

enhanced road safety as a result of climate change and weather-related transport sector impacts. In the present study an R-value of 0.120 suggests that the independent variable, climate change, contributes to explaining the variation in maritime transportation, as exposed in the template immediate in Table 4.17. This suggests a noteworthy link between climate change and marine transportation. On the other hand, (Singh, 2012, pp.297-302) stated that transportation is a major source of air pollution and health problems caused by emissions from oceangoing ships. A thorough comprehension of fuel usage, atmospheric composition, and trade-offs is necessary for effective emission regulation. With a statistically significant F-value of 4.338 ($p = 0.038$), the regression model accurately predicts maritime transportation, according to the ANOVA findings in Table 4.18. As a result, we have empirical confirmation that weather shift has a major impact on maritime traffic.

Huttunen et al., (2015, pp.168-181) noted that the Baltic Sea watershed is anticipated to have an increase in runoff, a decrease in snow cover, and a rise in nutrient leaching from both natural and agricultural sources due to climate change. There may be an imbalance in nutrients due to optimum adaptation, and there may be an increase in leaching due to suboptimal adaptation. In support of the previous study, Table 4.19 shows the climate-related coefficients, which lend credence to these conclusions. With a beta value of -0.120, we may infer that there is a negative correlation between maritime traffic and climate change, meaning that it declines in tandem with the latter. Furthermore, the coefficient is "statistically significant ($p = 0.038$) with a t-value of -2.083," further supporting the idea that climate change significantly impacts maritime traffic. Ultimately, the data lend credence to the alternative hypothesis (H1c) that climate change does, in fact, significantly affect agricultural productivity, which in turn affects maritime traffic. Climate change, agricultural output, and maritime transportation are all intricately linked, and these results show how critical it is to address adaptation and mitigation strategies for climate change within the maritime industry.

5.4 Discussion of Research Question Four

What effect does sea level rise have on coastal erosion and accretion?

Results from Tables 4.20 and 4.21 support the idea that disruptions in oil transportation caused by climate change will have an impact on marine traffic. (Walker, 2019, pp. 505-530) emphasized that air pollution, greenhouse gas emissions, and ship-strikes are some of the environmental problems caused by marine transportation, which is responsible for moving more than 10 billion tons of goods every year. To tackle these problems, preventative actions were being taken. Similarly in the present study, the descriptive data of oil transportation (mean score of 24.59) and climate change (mean score of 25.05) are shown in Table 4.20. Moreover, the positive association between climate change and oil transportation is statistically significant ($r = 0.277$, $p < 0.01$), as shown in Table 4.21. It follows that oil transportation interruptions are likely to increase in tandem with the rate of climate change. There is a direct correlation between problems with oil transportation and problems with marine transportation.

Mou (2020, pp.181311-181325) examined the shipping network for crude oil along the Maritime Silk Road, demonstrating how the architecture of a network influences its robustness. Size and connectedness have a beneficial effect on resilience, but centrality and network density have a negative one. Resilience is improved by fortifying medium- and small-sized ports. According to these findings, “there is a strong correlation between climate change and oil transportation” interruptions, which impact marine traffic (H1d). Climate change mitigation initiatives may help lessen interruptions in oil transportation and the resulting effects on marine transportation (correlation coefficient: 0.277, indicating a somewhat favourable link between the variables). Taken together, these results demonstrate how climate change, disruptions in oil transportation, and maritime transportation are all interdependent, underscoring the need of

taking preventative actions to deal with climate change and make sure that marine transportation systems can withstand environmental changes.

5.5 Discussion of Research Question Five

What steps are being taken to address the possible harm that climate change could cause to the maritime industries?

It will need a multipronged effort, combining several plans and programs, to mitigate the damage that climate change could do to the marine industry. To lessen the blow that climate change will deal to the marine industry, several measures are being implemented:

1. Adaptation Measures: Taking action to address the immediate consequences of climate change, such as altered ocean conditions, more frequent and severe weather events, and higher sea levels. As part of this effort, we must strengthen emergency response systems, upgrade port infrastructure, and construct more robust infrastructure.

2. Minimizing Emissions: Pollutants from the marine sector are a major cause of global warming. Cleaner fuels, more efficient engines, and technical solutions like scrubbers, ships fuelled by LNG, and research into alternative energy sources like ammonia and hydrogen are all part of the effort to lower ship emissions.

3. Regulatory Frameworks: International regulatory organizations, such as the International Maritime Organization (IMO), are enacting rules to decrease ship emissions. The International Maritime Organization (IMO) has taken many steps toward reducing emissions of greenhouse gases from ships, including the approval of the Energy Efficiency Design Index (EEDI) and the execution of the Initial IMO Strategy on Reduction of GHG Emissions from Ships.

4. Research and Development: Spending money on R&D to create new innovation and solutions that the marine industry can use to change to and lessen the impacts of “climate change.” Sustainable shipping methods, autonomous ships, renewable energy, and alternative fuels are all part of this initiative.

5. International Collaboration: Working together, governments, businesses, and international organizations can address the climate change issues that the marine sector is experiencing. As part of this effort, we are exchanging data, knowledge, and best practices to solve global problems.

6. Climate Resilience Planning: Making preparations for, and responses to, climate change by working to reduce the likelihood of, and damage to, supply chains, infrastructure, and operations in the marine sector. This necessitates taking climate into account while making decisions and plans for the future, as well as determining potential weak spots and how to fix them.

7. Public Awareness and Education: It entails educating the public, lawmakers, and stakeholders in the marine sector about the dangers and consequences of climate change. Fostering a culture of adaptability and resilience and supporting sustainable practices are all part of this.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 "Summary of the Study"

Chapter 1 (Introduction): This chapter discussed the "Impact of Climate Change on Marine Industry". This chapter describes climate change and its effects on marine ecosystems, Fishers, and Marine Transportation Industries. The chapter discussed the key impacts of climate change on the marine economy. The chapter defined the Impact of Climate Change on Marine Industries. The chapter included climate change had an adverse impact on the coastal and marine environments and their tourism. The chapter, with reference to Global Summit and Policies, marine species, and Global warming assessed the impacts of climate change.

Chapter 2 (Review of Literature): This chapter presented the study of relevant text that helped the researcher establish connections with the body of information already available on the subject or field subject matter being investigated. To provide a complete overview of what has been learned about a topic, a review of the relevant literature is conducted. It justified the study's problem selection. The chapter included all "prior research regarding" all the variables such as "Sea level rise, Agricultural Output, Ocean temperature changes, Extreme weather events (hurricanes, cyclones, storm surges), Changes in marine biodiversity and ecosystems, Impacts on fisheries and aquaculture, Disruption of maritime transportation routes, Damage to coastal infrastructure Risks to maritime safety, Changes in shipping routes and operations, Changes in coastal tourism patterns, Socioeconomic consequences for coastal communities". To summarize the review of literature, it can be said that much research has been undertaken on various elements of the function of climate change and the marine industry. "The objectives, methods, and results of the reviews supplied by various authors were reviewed in this chapter."

Chapter 3 (Research Methodology): The chapter describes the technique and types of data, data-gathering strategies, study area, and methodologies. “Primary and secondary data” were used to achieve the study's objectives. The conceptual framework and research methodologies were covered in this chapter. The conceptual project and research layout were also employed in this section. The study was performed in India. Coastguards, merchants, sailors, and anglers of India were the targeted population in this study. “The sample size of the study was 300 respondents.” A stratified random sampling technique and mixed-method research design were used in the study. Excel and SPSS were used the statistical software in the study. The study included several tools for data analysis such as Standard Deviation, Arithmetic Mean, Correlation, and Regression used to conduct the research.

Chapter 4 (Data Analysis and Interpretation): The chapter addressed the hypothesis, validity, reliability, and objectivity of the study and covered a span of “statistical tools and techniques for gathering data.” With the use of several tests, the necessary data were gathered in order to further the study's aims and evaluate the hypotheses. Main research on the effects of climate change on the maritime industry was chosen for the project. A discussion of the results utilizing a variety of statistical approaches was presented in this chapter. The data were processed using "the arithmetic mean, standard deviation, regression, and correlation."

6.2 Implications of the Study

The study of climate change's effects on the maritime sector has numerous and significant implications. A better grasp of these effects can first alert influential people in government, business, and other sectors to the critical need for swift action in the form of adaptation and mitigation strategies. To reduce risks and increase resilience, the marine sector must first be aware of its exposure to climate change. Second, sustainable development practices may be fostered by addressing the suggestions of environment adjustment on the

marine sector. This will ensure that marine ecosystems and resources are viable in the long run. Thirdly, protecting marine-based businesses like fishing, tourism, and shipping from the worst effects of climate change can have good socioeconomic consequences.

Furthermore, renewable energy, coastal conservation, and sustainable fisheries management are three areas that stand to benefit economically, technologically, and in terms of new jobs created by climate change initiatives in the maritime sector. By reducing the adverse effects of atmosphere change on the ocean, one can save at-risk coastal populations, keep ecological services that are essential to human survival, and keep biodiversity alive. If one cares about environmental preservation, economic growth, and social justice for generations to come, one must acknowledge and resolve the climate change's effects on the maritime sector.

6.3 Suggestions and Recommendations

The suggestions and recommendations of the study for the companies are as follows:

a) Reduce greenhouse gas emissions from ships and other businesses that are accelerating global warming by enacting and strictly enforcing stronger laws.
b) In order to better track and evaluate the effects of environment adjustment on maritime ecosystems and industry, it is necessary to improve monitoring and surveillance systems.
c) The marine sector needs your help in preparing for and responding to the impacts of climate change, so put some money into R&D projects that will create new technology and solutions.
d) In order to combat the worldwide effects of climate change on the maritime industry, governments, businesses, and other organizations must work together on a global scale.
e) To protect marine resources from the effects of climate change for future generations, fisheries and aquaculture must be managed sustainably.

f) Make coastal infrastructure and communities more resilient and adaptable so they can better handle climate-related risks like rising sea levels and intense weather.

g) Bring attention to the need to mitigate the effects of climate change on the maritime sector and inform relevant parties of the advantages of adopting preventative action.

h) The maritime industry needs your help to recognize and lessen the impact of global warming, so make sure they get enough money.

i) Reduce the social and economic toll that climate change will have on coastal communities and maritime businesses by planning for and executing thorough risk management methods.

j) Promote research and collaboration across disciplines to get a deeper understanding of the interplay between climate change, marine ecosystems, and human activities.

6.4 Conclusion

A conclusion is the last section of the thesis that brings together the main ideas, arguments, or points discussed. A conclusion is not simply a summary of the points or a restatement of the research problem; rather, it is a synthesis of the important points. Usually, the closing portion and last major subdivision of discussion consist of a concise recapitulation of the key arguments and an expression of judgment or conclusions. This section acts as a summative reflection, offering closure to the reader. It serves to underscore the significance of the research, often exploring broader implications and potential applications. Additionally, the conclusion may candidly acknowledge any limitations inherent in the study, demonstrating a nuanced understanding of its scope. This chapter presents a concise overview of the study, offers suggestions for future actions, presents the results, draws a conclusion, acknowledges any limits, and discusses the potential consequences.

The marine sector is facing serious problems as a result of climate change, which is affecting many parts of marine ecosystems, resources, and activities. As a result of the polar

ice caps melting and the thermal expansion of saltwater, one of the most noticeable effects of climate change on the maritime sector is the increase in sea levels. Marine infrastructure, coastal towns, and maritime transit routes are all negatively impacted by this phenomenon, which causes coastal erosion, floods low-lying regions, and destroys coastal ecosystems. The effects of climate change on ocean acidity and temperature levels will have far-reaching consequences for marine life, fishing, and aquaculture. Changes in the distribution and number of marine species, especially fish populations of economic importance, are disrupted by rising water temperatures, which destabilize marine ecosystems. Corals and molluscs, which have shells made of calcium carbonate, are particularly vulnerable to the effects of ocean acidification, which threatens marine biodiversity and the proper functioning of ecosystems as a whole.

Climate change is causing storm surges, hurricanes, and cyclones to become more intense, which is another major problem for the maritime sector. Coastal infrastructure, ships, and offshore installations are vulnerable to these disasters, which can impede oceanic processes and imperil mariners. Freight, seaports, offshore power, and coastal tourism are all areas that are affected by climate change. Shipping routes, port operations, and offshore activities are all impacted by changes in weather patterns, sea ice conditions, and ocean currents. As a result, the maritime sectors face increasing risks, operational issues, and expenses.

APPENDIX A

SURVEY COVER LETTER

Dear respondents, I am a doctoral research scholar at SSBM Geneva, seeking your opinions on the topic of climate change's impact on the marine industry. If you are involved in the marine industry or related to the marine industry, or who is interested in climate change's impact on the marine industry. Please help me complete this survey. Your input is incredibly important, and I would greatly appreciate it if you could spare approximately 10 minutes of your time to answer the provided questions. Thank you.

“Please express the degree to which you feel the following emotions using a five-point Likert scale ranging from 1-5, where 1= Strongly Agree (SA), 2= Agree(A), 3= Neutral (N), 4=Disagree (D), 5= Strongly Disagree (SD).”

- **Demographic Profile of Respondents**

1. Gender:

a) Male
b) Female

2. Age:

a) Less than 18
b) 18-34
c) 35-54
d) 55 or over

3. Education Level:

a) High School or equivalent
b) Bachelor's Degree
c) Master's Degree or higher
d) Other Specify _____

4. Occupation within the marine industry:

a) Fisherman/Fisherwoman

b) Coastal Engineer

c) Marine Technician

d) Other Specify _____

5. Years of experience in the marine industry:

a) “Less than 1 year

b) 1-5 years

c) 6-10 years

d) More than 10 years”

6. Primary Role in the marine industry:

a) Management/Executive

b) Research/Science

c) Operations/Fieldwork

d) Support/Administrative

7. Income Level:

a) Below ₹25,000

b) ₹25,000 - ₹50,000

c) ₹50,001 - ₹75,000

d) Above ₹75,000

8. Familiarity with climate change issues:

a) Very Familiar

b) Somewhat Familiar

c) Not Familiar

9. Perception of the threat of climate change to the marine industry:

a) Significant Threat

b) Moderate Threat

c) Minor Threat

d) Not a Threat

10. Apprehension about the economic “impacts of climate change on the marine” industry:

a) Very Concerned

b) Somewhat Concerned

c) Not Concerned

- **Climate Change**

Please Give your Response Regarding the climate change

S No.	Climate change	SA	A	N	D	SD
1.	Climate change is a significant concern for the marine industry.					
2.	Taking measures to address climate change is essential for the sustainability of the marine industry.					
3.	I support initiatives aimed at "reducing greenhouse gas emissions to mitigate climate change effects on the marine environment."					
4.	Governments should prioritize policies and regulations to address climate change impacts on the marine industry.					
5.	Implementing climate-resilient infrastructure in coastal areas is crucial for adapting to the effects of climate change.					
6.	I believe that public awareness and education regarding climate change in the marine industry are essential.					
7.	Collaboration between governments, industries, and scientific communities is necessary to effectively address climate change in the marine sector.					

- **Impact on the marine industry from climate change**

Please Give a Response Regarding the impact of climate change on the maritime industry

S No.	Impact	SA	A	N	D	SD

1.	I believe that climate change poses a threat to the sustainability of maritime operations.					
2.	The economic consequences of climate change affect the maritime industry.					
3.	"Implementing adaptation measures is crucial for the resilience of the maritime industry against climate change effects"					
4.	The impacts of "climate change on marine operations" should be a top legislative priority for governments.					
5.	The future of the marine sector depends on investments in coastal and port infrastructure					
6.	I believe that raising public awareness about climate change's impacts on the maritime industry is necessary					
7.	Investing in research and development of innovative technologies can help mitigate the impacts of climate change on the maritime industry.					

- ## Erosion and Accretion along the Coastal Zone

Please Give a Response Regarding the erosion and accretion along the coastal zone

S No.	Erosion and accretion	SA	A	N	D	SD
1.	Erosion and accretion processes significantly impact coastal communities					
2.	Coastal erosion poses a threat to infrastructure along the shoreline					
3.	Accretion of sediment along the coast can provide natural protection against erosion					
4.	Implementing coastal protection measures is essential to mitigate the impacts of erosion					

5.	Community involvement and awareness are crucial for addressing erosion and accretion issues					
6.	Sustainable coastal management practices can help minimize the impacts of erosion and accretion on coastal ecosystems					
7.	Coastal communities should have access to information and resources to adapt to changing erosion and accretion patterns					

- ## Sea Level Rise

Please Give a Response Regarding the rise in sea levels

S No.	Sea level rise	SA	A	N	D	SD
1.	Sea level rise is a significant concern for coastal communities					
2.	Taking measures to mitigate sea level rise is crucial for the resilience of coastal areas					
3.	I believe that sea level rise affects the postal communities					
4.	I think that Coastal towns should be prioritized to reduce the consequences of sea level rise.					
5.	Investing in infrastructure that can withstand rising sea levels is necessary for coastal resilience					
6.	I believe that public awareness and education regarding sea level rise are essential for coastal planning					
7.	I think that in the future sea levels will rise					

- ## Marine Transportation

Please Give a Response Regarding the marine transportation

S No.	Marine transportation	SA	A	N	D	SD
1.	Marine transportation plays a crucial role in global trade and commerce					
2.	I believe that efficient marine transportation systems are vital for economic growth					
3.	Improving the infrastructure for marine transportation can lead to enhanced connectivity and accessibility					
4.	I support investments in sustainable practices for marine transportation to reduce environmental impacts					
5.	Marine transportation companies should prioritize safety measures to ensure the well-being of passengers and crew					
6.	I believe that advancements in digital technologies can improve the efficiency and safety of marine transportation operations					
7.	Public awareness campaigns should highlight the importance of sustainable practices in marine transportation					

- ## Oil Transportation

Please Give a Response Regarding Oil transportation.

S No.	Oil Transportation	SA	A	N	D	SD
1.	Oil transportation contributes significantly to marine pollution.					
2.	The increase in extreme weather events due to climate change poses a risk to oil transportation in marine environments.					
3.	Climate change has led to changes in sea levels, affecting the efficiency and safety of oil transportation.					

4.	The marine industry should invest more in developing environmentally friendly methods for oil transportation to mitigate climate change impacts.					
5.	Governments should enforce stricter regulations on oil transportation to reduce its contribution to climate change.					
6.	The marine industry should prioritize using cleaner energy sources for powering vessels involved in oil transportation.					
7.	Technology advancements can play a significant role in minimizing the environmental impact of oil transportation in the face of climate change.					

"I sincerely appreciate your time and cooperation.

Please check to make sure that all the questions are answered.

Thank you so much for your contribution."

REFERENCES

Abbass, K. et al., (2022) ‘A review of the global climate change impacts, adaptation, and sustainable mitigation measures’, *Environmental Science and Pollution Research*, 29(28), pp.42539-42559.

Alcock, R., (2003) *The effects of climate change on rocky shore communities in the Bay of Biscay, 1895-2050* (Doctoral dissertation, University of Southampton).

Allan, G.J., Lecca, P., McGregor, P.G. and Swales, J.K., (2014) ‘The economic impacts of marine energy developments: a case study from Scotland’, *Marine Policy*, *43*, pp.122-131.

Allison, E.H. and Bassett, H.R., (2015) ‘Climate change in the oceans: human impacts and responses’, *Science, 350*(6262), pp.778-782.

Amelung, B., Moreno, A. and Scott, D., (2008) ‘The place of tourism in the IPCC Fourth Assessment Report: A review’, *Tourism Review International, 12*(1), pp.5-12.

Anadi, (2024) ‘Intersecting Tides’, *climate change and maritime trade in Indio – Pacific 2040*, pp. 1-8.

Anderson, J. et al., (2013) ‘Modeling climate change impacts on phenology and population dynamics of migratory marine species’, *Ecological Modelling, 264*, pp.83-97.

Anthony, K.R. et al., (2015) ‘Operationalizing resilience for adaptive coral reef management under global environmental change’, *Global change biology, 21*(1), pp.48-61.

Apostolou, P., Cybersecurity in Maritime Industry. (2021)

Austin Becker et at., (2018) ‘Climate change Adaptation and seaports’, *Implications of climate change for shipping: ports and supply chain*, p.9(2).

Astrup, O.C., Wahlstrøm, A.M. and King, T., (2015) 'November. A framework addressing major accident risk in the Maritime industry', In *SNAME Maritime Convention* (p. D031S010R015). SNAME.

Attrill, M.J., (2002) 'Community-level indicators of stress in aquatic ecosystems', *biological indicators of aquatic ecosystem stress*, pp.473-508.

Azevedo de Almeida, B. and Mostafavi, A., (2016) 'Resilience of infrastructure systems to sea-level rise in coastal areas: Impacts, adaptation measures, and implementation challenges', *Sustainability, 8*(11), p.1115.

Barton, B.A., Morgan, J.D. and Vijayan, M.M., (2002) 'Physiological and condition-related indicators of environmental stress in fish', Biological indicators of aquatic ecosystem stress, pp.111-148.

Beardall, J. and Raven, J.A., (2004) 'The potential effects of global climate change on microalgal photosynthesis, growth and ecology', *Phycologia, 43*(1), pp.26-40.

Becken, S., (2013) 'A review of tourism and climate change as an evolving knowledge domain', *Tourism Management Perspectives, 6*, pp.53-62.

Becken, S., et al. (2013) 'Climate change and tourism: Impacts, adaptation, and mitigation Routledge',

Benamara, H., Hoffmann, J. and Youssef, F., (2019) 'Maritime transport: The sustainability imperative', *Sustainable shipping: A cross-disciplinary view*, pp.1-31.

Boatemaa, M.A., Kwasi, A.A. and Mensah, A., (2013) 'Impacts of shoreline morphological change and sea level rise on mangroves: the case of the Keta coastal zone', *Journal of Environmental Research and Management*, *4*(11), pp.359-367.

Bows-Larkin, A. (2015) 'All adrift: aviation, shipping, and climate change policy', *Climate Policy, 15*(6), 681-702.

Brammer, H., (2014) 'Bangladesh's dynamic coastal regions and sea-level rise', *Climate risk management*, *1*, pp.51-62.

Cavanagh, R.D. et al., (2021) 'Future risk for Southern Ocean ecosystem services under climate change', *Frontiers in Marine Science*, *7*, p.615214.

Chavez, F.P., Ryan, J., Lluch-Cota, S.E. and Ñiquen C, M., (2003) 'From anchovies to sardines and back: multidecadal change in the Pacific Ocean', *science*, *299*(5604), pp.217-221.

Cochran, W. G. (1977) *Sampling techniques*. John Wiley & Sons.

Cooper, M.J., Beevers, M.D. and Oppenheimer, M., (2008) 'The potential impacts of sea level rise on the coastal region of New Jersey, USA', *Climatic Change*, *90*(4), pp.475-492.

Crépin, A.S., Karcher, M. and Gascard, J.C., (2017) 'Arctic climate change, economy and society (ACCESS): Integrated perspectives', *Ambio*, *46*, pp.341-354.

Doney, S.C., Fabry, V.J., Feely, R.A. and Kleypas, J.A., (2009) 'Ocean acidification: the other CO2 problem', *Annual review of marine science*, *1*, pp.169-192.

Elliott, J. et al., (2014) 'Constraints and potentials of future irrigation water availability on agricultural production under climate change', *Proceedings of the National Academy of Sciences*, *111*(9), pp.3239-3244.

Emanuel, K.A., (2013) 'Downscaling CMIP5 climate models shows increased tropical cyclone activity over the 21st century', *Proceedings of the National Academy of Sciences*, *110*(30), pp.12219-12224.

Enete, I.C., (2014) 'Impacts of climate change on agricultural production in Enugu State, Nigeria', *Journal of Earth Science & Climatic Change*, *5*(9), p.234.

Ezinna, P. C., Nwanmuoh, E., & Ozumba, B. U. I. (2021) 'Decarbonization and sustainable development goal 13: A reflection of the maritime sector', *Journal of International Maritime Safety, Environmental Affairs*, *and Shipping*, *5*(2), 98-105.

Agriculture Organization of the United Nations. Fisheries Department, (2000) *The State of World Fisheries and Aquaculture*, *2000*. Food & Agriculture Org.

GLOBEC. (2003) 'Marine Ecosystems and Global Change IGBP', Science 5: 1-32.

Gornitz, V., (1991) 'Global coastal hazards from future sea level rise', *Palaeogeography*, *Palaeoclimatology*, *Palaeoecology*, *89*(4), pp.379-398.

Guo, H., Xia, Y., Jin, J. and Pan, C., (2022) 'The impact of climate change on the efficiency of agricultural production in the world's main agricultural regions', *Environmental Impact Assessment Review*, *97*, p.106891.

Habib-ur-Rahman, M., Ahmad, A., Raza, A., (2022) 'Impact of climate change on agricultural production; Issues, challenges, and opportunities in Asia', *Frontiers in Plant Science*, *13*, p.925548.

Haites, E., (2009) 'Linking emissions trading schemes for international aviation and shipping emissions', *Climate Policy*, *9*(4), pp.415-430.

Han, C. H. (2010) 'Strategies to reduce air pollution in shipping industry', *The Asian Journal of Shipping and Logistics*, *26*(1), 7-29.

Hare, S.R. and Mantua, N.J., (2000) 'Empirical evidence for North Pacific regime shifts in 1977 and 1989', *Progress in oceanography*, *47*(2-4), pp.103-145.

Holbrook, N. J., & Johnson, J. E. (2014) 'Climate change impacts and adaptation of commercial marine fisheries in Australia: a review of the science', *Climatic change*, *124*(4), 703-715.

Horn, M.H., (1999) Herbivory. Intertidal Fishes, Life in two worlds, pp.197-222.

Horn, M.H., Chotkowski, M.A. and Martin, K.L. eds., (1999) 'Intertidal Fishes: Life in Two Worlds. Academic',

Huttunen, I. et al., (2015) 'Effects of climate change and agricultural adaptation on nutrient loading from Finnish catchments to the Baltic Sea', *Science of the Total Environment*, *529*, pp.168-181.

ICES. (2003) 'Report of the ICES advisory committee on Ecosystems, ICES Cooperative Research Report',

IPCC (2014) 'Climate Change 2014: Synthesis Report, Summary for Policymakers',

IPCC (Intergovernmental Panel on Climate Change) (2001) 'Coastal zones and marine ecosystems', In: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (ed.), Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, UK, 1032 pp.

IPCC, 2007b. Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J. And Handson, C.E. (Eds.) Cambridge, UK.

IPCC. (2019) 'Special Report on the Ocean and Cryosphere in a Changing Climate',

Jiménez, J.A., Valdemoro, H.I., Bosom, E., Sánchez-Arcilla, A. and Nicholls, R.J., (2017) 'Impacts of sea-level rise-induced erosion on the Catalan coast', *Regional environmental change*, *17*, pp.593-603.

Ju, H. et al., (2013) 'The impacts of climate change on agricultural production systems in China', *Climatic Change*, *120*, pp.313-324.

Kechagias, E.P., Chatzistelios, G., Papadopoulos, G.A. and Apostolou, P., (2022) 'Digital transformation of the maritime industry: A cybersecurity systemic approach', *International Journal of Critical Infrastructure Protection*, *37*, p.100526.

Keith, D. J. (2020) 'Coastal and Estuarine Waters: Optical Sensors and Remote Sensing', In *Coastal and Marine Environments* (pp. 51-59). CRC Press.

Kelly, R., Pecl, G. T., & Fleming, A. (2017) 'Social licence in the marine sector: a review of understanding and application', *Marine Policy*, *81*, 21-28.

Kennedy, V.S., Twilley, R.R., Kleypas, J.A., Cowan Jr, J.H. and Hare, S.R., (2002) *Coastal and marine ecosystems & global climate change*. 'Pew Center on Global Climate Change',

Kennedy, V.S., Twilley, R.R., Kleypas, J.A., Cowan Jr, J.H. and Hare, S.R., (2002) 'Coastal and marine ecosystems & Global climate change: Potential Effects on US Resources',

Koetse, M.J. and Rietveld, P., (2009) 'The impact of climate change and weather on transport: An overview of empirical findings', *Transportation Research Part D*: *Transport and Environment*, *14*(3), pp.205-221.

Kong, H., Yang, W., Zhang, P. and Peng, R., (2018) 'Impact of Climate Change on Major Marine Industries', In *E3S Web of Conferences* (Vol. 53, p. 03072). EDP Sciences.

Kumar, R. and Gautam, H.R., (2014) 'Climate change and its impact on agricultural productivity in India', *Journal of Climatology & Weather Forecasting*, *2*(1), pp.1-3.

Kumar, V., Ranjan, D., & Verma, K. (2021) 'Global climate change: the loop between cause and impact', In *Global Climate Change* (pp. 187-211). Elsevier.

Kum fai yuen., (2017) 'Supply chain integration', *Barriers to supply chain integration in the maritime logistics industry*., August, p.19(3).

Lachaud, M.A., Bravo-Ureta, B.E. and Ludena, C.E., (2022) 'Economic effects of climate change on agricultural production and productivity in Latin America and the Caribbean (LAC)', *Agricultural Economics*, *53*(2), pp.321-332.

Leorri, E., Cearreta, A., García-Artola, A., Irabien, M.J. and Blake, W.H., (2013) 'Relative sea-level rise in the Basque coast (N Spain): Different environmental consequences on the coastal area', *Ocean & coastal management*, *77*, pp.3-13.

Lister, J., Poulsen, R.T. and Ponte, S., (2015) 'Orchestrating transnational environmental governance in maritime shipping', *Global Environmental Change*, *34*, pp.185-195.

Liu Xiancheng. (2012) 'Degree paper of Dalian Maritime University',

Lussi, A., & Jaeggi, T. (2008) 'Erosion—diagnosis and risk factors', *Clinical oral investigations*, 12, 5-13.

Mahapatra, M., Ramakrishnan, R. and Rajawat, A.S., (2015) 'Coastal vulnerability assessment of Gujarat coast to sea level rise using GIS techniques: a preliminary study', *Journal of coastal conservation*, *19*, pp.241-256.

Manadiar, H., (2020) 'Effects of climate change', *Adverse of climate change on maritime transport*, 1January, pp. 1-10.

Mandegarian, F., et al. (2020) 'Vulnerability assessment of coastal tourism infrastructure under climate change and sea-level rise: A case study of Cartagena, Colombia', *Journal of Sustainable Tourism*, 1-21.

McGinn, N.A. (2002) 'Fisheries in a Changing Climate', American Fisheries Society Symposium 32, Bethesda, MD, 295 pp.

Messner, S., (2020) 'Future Arctic shipping, black carbon emissions, and climate change', In *Maritime Transport and Regional Sustainability* (pp. 195-208). Elsevier.

Miller, K.A. and Fluharty, D.L., (1992) 'El Niño and variability in the northeastern Pacific salmon fishery: implications for coping with climate change', *Climate variability*, *climate change and fisheries*. *Cambridge University Press*, *Cambridge*, pp.49-88.

Miola, A., Marra, M., & Ciuffo, B. (2011) 'Designing a climate change policy for the international maritime transport sector: Market-based measures and technological options for global and regional policy actions', *Energy Policy*, *39*(9), 5490-5498.

Mocerino, L., Quaranta, F. and Rizzuto, E., (2018) 'Climate changes and maritime transportation: A state of the art', *Technology and Science for the Ships of the Future*, pp.1005-1013.

Monios, J. and Wilmsmeier, G., (2020) 'Deep adaptation to climate change in the maritime transport sector–a new paradigm for maritime economics?', *Maritime Policy & Management*, *47*(7), pp.853-872.

Moreira, P.P., 2014. The social and environmental sustainability of the maritime industry.

Moreno, A. and Amelung, B., (2009) 'Climate change and coastal & marine tourism: Review and analysis', *Journal of Coastal Research*, pp.1140-1144.

Mou, N. et al., (2020) 'Assessment of the resilience of a complex network for crude oil transportation on the Maritime Silk Road', *IEEE Access*, *8*, pp.181311-181325.

Mukherjee, D. (2012, January 1) The emerging legal regime in global warming a study.

Murawski, S.A., (1993) 'Climate change and marine fish distributions: forecasting from historical analogy', *Transactions of the American Fisheries Society*, *122*(5), pp.647-658.

Nguyen, H.D. et al., (2020) 'IMPACTS OF URBANIZATION AND TOURISM ON THE EROSION AND ACCRETION OF EUROPEAN, ASIAN AND AFRICAN COASTAL

AREAS AND POSSIBLE SOLUTIONS', *Urbanism. Architecture. Constructions/Urbanism. Arhitectura. Constructii*, *11*(2).

Nian, V. and Yuan, J., (2017) 'A method for analysis of maritime transportation systems in the life cycle approach–The oil tanker example', *Applied energy*, *206*, pp.1579-1589.

Nicholls, R.J. et al., (2010) Sea-level rise and its possible impacts given.

Nicholls, R.J. et al., (2011) 'Sea-level rise and its possible impacts given a 'beyond 4 C world'in the twenty-first century', *Philosophical transactions of the Royal Society A*: *mathematical, physical and engineering sciences*, *369*(1934), pp.161-181.

Ozdemir, D., (2022) 'The impact of climate change on agricultural productivity in Asian countries: a heterogeneous panel data approach', *Environmental Science and Pollution Research*, pp.1-13.

Panitchpakdi, S., (2009) 'United Nation Conference on Trade and Development', *Maritime Transport*, 1 December. Pp. 17-19.

Patterson, T., Bastianoni, S. and Simpson, M., (2006) 'Tourism and climate change: Two-way Street, or vicious/virtuous circle?', *Journal of Sustainable Tourism*, *14*(4), pp.339-348.

Pauly, D. and Christensen, V., (1995) 'Primary production required to sustain global fisheries', *Nature*, *374*(6519), pp.255-257.

Pauly, D. and Christensen, V., (1995) 'Primary production required to sustain global fisheries (vol 374, pg. 255, 1995)', *Nature*, *376*(6537), pp.279-279.

Pramanik, M.K., Biswas, S.S., Mondal, B. and Pal, R., (2016) 'Coastal vulnerability assessment of the predicted sea level rise in the coastal zone of Krishna–Godavari delta region, Andhra Pradesh, east coast of India', *Environment*, *development and sustainability*, *18*, pp.1635-1655.

Reardon, T., & Timmer, C. P. (2007) 'Transformation of markets for agricultural output in developing countries since 1950: How has thinking changed?', *Handbook of agricultural economics*, *3*, 2807-2855.

Regan, P.M., Kim, H. and Maiden, E., (2019) 'Climate change, adaptation, and agricultural output', *Regional Environmental Change*, *19*, pp.113-123.

Richardson, A.J. and Schoeman, D.S., (2004) 'Climate impact on plankton ecosystems in the Northeast Atlantic', *Science*, *305*(5690), pp.1609-1612.

Rongshuo, C. and Qinghua, Q., (2014) 'Key points on impact assessment of climate change on the ocean and related adaptation from the IPCC Working Group II Fifth Assessment Report', *Advances in Climate Change Research*, *10*(3), p.185.

Rose, G.A. and Leggett, W.C., (1988) 'Atmosphere–ocean coupling and Atlantic cod migrations: effect of wind-forced variations in sea temperatures and currents or nearshore distributions and catch rates of Gadus morhua', *Canadian Journal of Fisheries and Aquatic Sciences*, *45*(7), pp.1234-1243.

Saether, E.A., Eide, A.E. and Bjørgum, Ø., (2021) 'Sustainability among Norwegian maritime firms: Green strategy and innovation as mediators of long-term orientation and emission reduction', *Business Strategy and the Environment*, *30*(5), pp.2382-2395.

Sahya et al., (2021) 'Climate change effects on Aquaculture Production', *Sustainability Implications, Mitigation, and Adoptions*, 12 March. Pp. 2-8.

Schnurr, R.E. and Walker, T.R., (2019) 'Marine transportation and energy use', *Reference Module in Earth Systems and Environmental Sciences*, pp.1-9.

Science Press. (1994) 'Division of Earth Science, Chinese Academy of Sciences', The impact of sea level rise on China's delta region and the countermeasures.

Secretariat, R.S., (2008) ‘Climate change: Challenges to sustainable development in India’, *Occasional Paper Series*, 3.

Shyam, S.S., Shridhar, N. and Fernandez, R., (2017) ‘Climate change and need for proactive policy initiatives in Indian marine fisheries sector’, *Climate Change*, *3*(9), pp.20-37.

Singh, V.K., (2012) ‘Climate change and its impact on agriculture: A review’, *International Journal of Agriculture*, *Environment and Biotechnology*, *5*(3), pp.297-302.

Siswanto, E., Horii, T., Iskandar, I., Gaol, J.L., Setiawan, R.Y. and Susanto, R.D., (2020) ‘Impacts of climate changes on the phytoplankton biomass of the Indonesian Maritime Continent’, *Journal of Marine Systems*, *212*, p.103451.

Soto, C.G., (2002) ‘The potential impacts of global climate change on marine protected areas’, *Reviews in Fish Biology and Fisheries*, *11*, pp.181-195.

Southward, A.J. and Boalch, G.T., (1994) ‘The effect of changing climate on marine life: past events and future predictions’, *Exeter Maritime Studies*, *9*, pp.101-143.

Southward, A.J., Hawkins, S.J. and Burrows, M.T., (1995) ‘Seventy years' observations of changes in distribution and abundance of zooplankton and intertidal organisms in the western English Channel in relation to rising sea temperature’, *Journal of thermal Biology*, *20*(1-2), pp.127-155.

Stephenson, S. R., et al., (2010) ‘Arctic shipping emissions inventories and future scenarios’, *Atmospheric Chemistry and Physics*, *10*(19), pp.9689-9704.

Stephenson, S. R., et al. (2013) ‘Arctic shipping emissions inventories and future scenarios’, *Atmospheric Chemistry and Physics*, *13*(16), 9689-9704.

Storbjörk, S. and Hedrén, J., (2011) 'Institutional capacity-building for targeting sea-level rise in the climate adaptation of Swedish coastal zone management', Lessons from Coastby. *Ocean & coastal management*, *54*(3), pp.265-273.

Suleria, H. A. R., Osborne, S., Masci, P., & Gobe, G. (2015) 'Marine-based nutraceuticals: An innovative trend in the food and supplement industries', *Marine drugs*, *13*(10), 6336-6351.

Sumaila, U. R., Cheung, W. W., Lam, V. W., Pauly, D., & Herrick, S. (2011) 'Climate change impacts on the biophysics and economics of world fisheries', *Nature climate change*, *1*(9), 449-456.

Sun Jiaqing. (2013) *Marine Technology*, (6): 73-75.

Timmermann, A. et al., (1999) 'Increased El Niño frequency in a climate model forced by future greenhouse warming', *Nature*, *398*(6729), pp.694-697.

Trathan, P.N. et al., (2015) 'Pollution, habitat loss, fishing, and climate change as critical threats to penguins', *Conservation Biology*, *29*(1), pp.31-41.

Valdivia, J., 1976. Aspectos biolo´ gicos del Feno´ meno El Nin˜ o 1972–73. Parte I: La poblacio´ n de anchoveta. In: Proceedings of the Workshop El Nin˜ o, Guayaquil, Ecuador, 4–12 December 1974. FAO Fishing Inf. 185, 80–93.

Vergara, J., McKesson, C., & Walczak, M. (2012) 'Sustainable energy for the marine sector', *Energy Policy*, *49*, 333-345.

Walker, T.R. et al., (2019) 'Environmental effects of marine transportation', In *World seas*: *an environmental evaluation* (pp. 505-530). Academic Press.

Wan, Z., El Makhloufi, A., Chen, Y., & Tang, J. (2018) 'Decarbonizing the international shipping industry: Solutions and policy recommendations', *Marine pollution bulletin*, *126*, 428-435.

Wang, N., Zhang, L.Q., Yuan, L. and Cao, H., (2012) 'Research into vulnerability assessment for coastal zones in the context of climate change', *Shengtai Xuebao/Acta Ecologica Sinica*, *32*(7), pp.2248-2258.

Wang, X., Yuen, K. F., Wong, Y. D., & Li, K. X. (2020) 'How can the maritime industry meet Sustainable Development Goals? An analysis of sustainability reports from the social entrepreneurship perspective', *Transportation Research Part D: Transport and Environment*, *78*, 102173.

Wang, Z., (2022 April) 'Influence of Climate Change on Marine Species and Its Solutions', In *IOP Conference Series*: *Earth and Environmental Science* (Vol. 1011, No. 1, p. 012053). IOP Publishing.

Watanabe, M.D., Hu, X., Ballal, V., Cavalett, O. and Cherubini, F., (2023) 'Climate change mitigation potentials of on grid-connected Power-to-X fuels and advanced biofuels for the European maritime transport', *Energy Conversion and Management*: *X*, *20*, p.100418.

Williams, S.J., (2013) 'Sea-level rise implications for coastal regions', *Journal of Coastal Research*, (63), pp.184-196.

Yacout, D.M., Tysklind, M. and Upadhyayula, V.K., (2021) 'Assessment of forest-based biofuels for Arctic marine shipping', *Resources*, *Conservation and Recycling*, *174*, p.105763.

Yadav, P., Jaiswal, D.K. and Sinha, R.K., (2021) 'Climate change: Impact on agricultural production and sustainable mitigation', In *Global climate change* (pp. 151-174). Elsevier.

Zhao Shiming, Liu Fuyou, Zhang Junhai, et al. (2008) *Journal of Ocean Technology*, *27*(3): 80-83.

Ziervogel, G. et al., (2014) 'Climate change impacts and adaptation in South Africa', *Wiley Interdisciplinary Reviews*: *Climate Change*, *5*(5), pp.605-620.

Zuta, S., Enfield, D., Valdivia, J., Lakes, P. and Blandin, C., (1974 December) ‘Physical aspects of 1972–73 El Nino event’, In *Proceedings of the Workshop El Nino*, *Guayaquil*, *Ecuador*, pp. 4-12.