

## Evaluating the Impact of Climate Change on Marine Transportation

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### Abstract

This study is aimed at identifying the impacts of climate change on world's maritime industries with its impacts on transportation, the role of sea level rise on erosion accretion in coastal belt and the possible remedial correction for the threats of climate change to the water transportation industries. The study was carried out basis on secondary resources and the use of qualitative methodology approach to find out some solutions that can be adapt to the problems. Climate change is a global threat for many reasons, with more intense heat waves and hurricanes facing our planet earth which is increasingly threatening the continuous existence of life on earth. This research was carried out on climate change and its impacts on transportation sector's contribution to global warming .System Analysis was used to link climate change and maritime transport. The study suggests necessary development plan and formulated policies to get optimum benefits out of the new navigating routs in the sea. Alternatives to emission targets reduction of GHG emission. Formulate effective adaptation and mitigation policies and implement it without delay was recommended.

***Keywords:*** Climate change, impacts, maritime transportation, environmental pollution

### 1. Introduction

Climate change has come to be one of the pressing challenges facing maritime industries on the planet. It continued to threat the existence of life and commerce industry. All nations of the global world are susceptible, some are even more vulnerable than the other, the existence coastal stretches with high susceptible sea level rise concentration of population. (Pelling and Blackburn 2013) Africa has been unprepared and usually overwhelmed by the magnitude of climate change

impacts (Adebayo 1998) Adefolalu etal 2007).

Recently, climate change represented one of earth greatest environmental and socio economic threats of Earth. World maritime industries focuses attention on the impact of shipping health safety, water transport security and environmental health value. The climate change due to the greenhouse gases emitted by maritime industry which the pollutant emissions from land based are decreased, while those from the maritime vehicles (shipping) are increased to become a future problem situation as

transport at sea increases yearly. Problems are more severe in coastal areas and especially seaports, dirty smokes pouring out from ships funnels have a major impact on the air quality of coastal communities. Oxides emitted to the air are responsible for the acid rain that affects sea water. The maritime industries are known for its vast marshlands vital for carbon sequestration, coastal erosion, rising seas and oil pollution are destroying the mangrove forest a major buffer against storm surge from the sea. With these risks linked to socio economic and physical factors, are frequent hazards from storms, sea level rise, flooding and GHG emission continue to threaten the region.

The current risk levels, physical and social assets face impending obliteration as coastal inundation threatens cities port-Harcourt and Lagos with other coastal areas that are lying low areas on the coast are projected to submerged unclear water by 2100. From their physical attributes, the proximity to the ocean and major rivers and economic potentials, coastal area in the south is more vulnerable to the menace of climate change confronting the industry. As there are increase in water vehicle (ships) risk will increase and exposures are expected to affect the community of coast maritime industry with carbon dioxide and methane emissions that come from the region warming temperature.

The coastal inundation significantly threatens maritime transportation and its coast, which has two hub mega cities, Lagos and Port-Harcourt which are major commercial capital, Lagos responsible for over 50% of the wealth is prone to ocean surge, while Port- Harcourt is the oil hub with over 620 oil fields of which 380 are shore and 230 offshore.

Flaring incidents emanating from oil production results in the emission of carbon dioxide in the maritime region which link between Green House Gas (GHG) emission, climate change, global temperature and sea level rise which result in rising temperature.

Rising temperature in the atmosphere causes sea level to rise and affects low lying coastal areas of the world. This led to flooding of the coastal infrastructure like ports, Port –facilitate the shipping industry, which is a commercial trade and transportation. Climate change can ultimately cause flooding of these ports, will dramatically affects shipping industries. The erosion and accretion caused by sea level rise and ice melting in the regions will change shipping transport routes and open possibility of oil exploration in the region.

These gases protect the heat coming from the sun to the earth surface to go back. Heat trapped by GHG's causes an increase in the temperature was observed on the terrestrial area .Sea Surface temperature (SST) display similar pattern (Schiermeier 2003) concludes that global sea surface temperatures were increasing by about 0.5 -1.0<sup>0</sup>C very million years at the time of ancient warming, known as the Paleocene /Eocene thermal Maximum (PETM) sea surface temperature rise observed by(IPCC, 2001b). Arise in temperature will contribute to global sea level rise (SLR). Climate change contributes to sea level rise mainly in two ways: -Thermal expansion of water and melting of glacial and mountain ice.

A study by Wigley and Raper (1987) estimated that the greenhouse gas induced thermal expansion caused as a level rise of 2.5cm during 1880 and 1985.They again

estimated a greenhouse gas induced global warming of  $0.6-1.0^{\circ}\text{C}$  for the period of 1985 -2025 and the resulting concomitant oceanic thermal expansion would raise sea level by 4-8 Cm. IPCC estimated that sea level rise would be 66Cm under business-as-usual conditions by 2100 with a range of uncertainty of 13 to 110cm. Sea level rose by 160mm through the 20<sup>th</sup> century (Church et al 2004, 2005) found a sea level rise of  $1.8\pm 0.3$  mm per year over 51-year period (1950- 2000). Church & White (2006) estimates sea level rise from January 1870 to December 2004 of 195 mm, a 20<sup>th</sup> Century rate of sea level rise from  $1.7\pm 0.3$ mm per year and a

significant acceleration of sea level rise of  $0.01\pm 0.006$  mm per year.

With constant rate of acceleration sea level rise from 1990 to 2100 would range from 280 to 340 mm. Tide gauge data show that global average sea level rose between 0.1 and 0.2 meters during the 20<sup>th</sup> Century (IPCC, 2001 b). Gornitz (1995) concluded that future sea level is expected to rise by similar to one meter.

Table 1. World's Global Warming (GW) and SLR Scenario

Model Assumption	GW Scenario by year ( $^{\circ}\text{C}$ )				SLR Scenario by year (cm)			
	2010	2030	2050	2100	2010	2030	2050	2100
Low	0.3	0.7	1.2	2.2	4	8	15	31
Business-as-usual	0.5	1.1	1.7	3.3	8	18	30	66
High	0.7	1.5	2.5	4.9	13	29	48	110
Source	Bretherton et al. cited in Warrick et al.				Warrick and Oerlemans, Cited in Warrick et al.			

(Source: Owoputi, 2020)

The extent, rate and nature of the morphological changes is expected to accelerate as it has been noted that they would lead to an accelerated rise in sea level of up to 0.6 meters or more by 2100 (Nicholls et al 2007). The interaction process for the marginally extreme 3m sea level rise scenario revealed that 18.88ha of land will be inundated with an average of  $9,442.77\text{m}^3$  volume of water which is expected inundation area for the 3m sea level is about 0.26% of the total study area and is presently occupied by scattered cultivation land use type.

Realizing the impacts on development, on the policy side, there is a growing

awareness on the need to integrate climate change indices onto national development. Ongoing increases in Carbon dioxide emission, a major greenhouse gas, is a key contributor to climate change responsible for the warning of the earth's surface. Sensitivity to climate change relates to how readily a particular system, react to change related to climate.

## 1.2 The Study Area

Maritime industry is a group of business sectors that are involved in maritime transport. The earth's surface is made up of the oceans and seas. A large area of earth's surface is used by humans, mainly

for fishing and transportation which includes shippers, shipbuilders, port authority, banks, insurance authority, maritime allied commercial activities, shipping transport and infrastructures that are facilitating shipping transport (seaport) as maritime industries. Shipping is the transfer of goods produced in one country to another country where those goods are in demand, which is responsible for the movement of 90% of global trade, (Ma, 2005).

As of present, the total numbers of world's merchant ships that are 300gt or more are 40,000 and carried 880 million dwt and 9.4 million TEU (ISL, 2005). Maritime industries contribute significantly to the economy of some countries. For example, this contributes 7% of Singapore's GDP and provides 120,000 jobs (Hua, 2004). Many countries depend on Maritime transport large for their growth and development.

As the shipping industry is using fossil fuels for energy, and even if those from road and air transport overshadow its emissions, it is still releasing a significant volume of GHG to the atmosphere. GHG emitted from ship is mainly CO<sub>2</sub>. The increasing trend of global emission have growth rate that affect climate change on transport/shipping and Maritime activities. Carbon dioxide emitted by Shipping sector is very minor when compared to other modes of transportation.

## 2. Materials and Methods

The research uses the system analysis or system dynamics (SD) which is a Methodology for exploring interpreting and managing complex feedback system to find out the impacts of climate change on

maritime industries to see the complexity of the system which is the causal loop diagram or mental model (CLD). In formulating a CLD factors involved in the system are identified first and then cause impacts of the factors are arranged in the mental model logically.

### 2.1 Impacts of Climate Change on Maritime Transportation

Most evidence shows that climate change will cause sea level rise in many of the major coastal zones of the world this will cause overflow of seawater through the coastal region which may wash out the topsoil of the area. (Kont et al 1997) concluded that the most vulnerable shore types to sea level rise are shoal, sandy, and silty shore being prone to erosion. Sea level will increase morphological activities in the coastal rivers, which will increase tidal flow in the coastal zone. Accelerated river flow will increase river bank erosion (Alam, 2003) mainly in the coastal area. Salinity intrusion in the coastal belt will cause destruction of mangrove forest of the area. A continuous deposition of silt to one place will form a creation of few lands in the area which will decrease water depth and make shipping difficult or ships coming to berth uneasy. Decreased water depth causes hindrance to normal movement of ships and gives restrictions in terms of ship sizes. Shallow water in the coastal area affects the activities of a seaport that minimize port performance. Erosion hinders port performance by removing port infrastructures, while decrease in port performance also decreases the shipping activities.

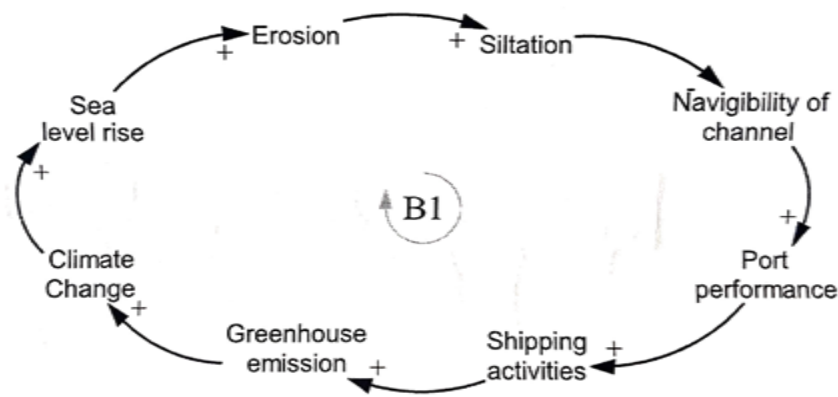


Figure 1. CLD Showing the relationships among shipping activities, climate change, sea level rise and other factors (LOOP)

1.8% of world total carbon dioxide was emitted by shipping sector though the figure is not big in percentage, it is significant in terms of volume and shows that maritime transportation contributes to climate change by emitting greenhouse gases. Climate change also causes a rise in sea surface temperature weather events such as cyclones. With an increase in cyclone intensity, its degree of damage by cyclone will increase.

Sea level rise induced floods and cyclones are natural hazards that decrease maritime security. The maritime security is mainly operational safety and security of ships and physical security of seafarers,

especially from pirates or terrorist attack (Bermen, 2006). Climate change is a natural hazard that imposes danger to maritime industries that cause security threat to the water transportation by reducing shipping activities. Natural disaster is an important factor for the loss of maritime security leading to loss of lives and assets, while shipping activities emit greenhouse gases that contribute to climate change. If climate change driven natural hazards are considered, whatever the form is, a loop of a different bias is revealed. The costs within the shipping sectors have gone up in terms of insurance premiums, as an effect of the implication of natural hazards.

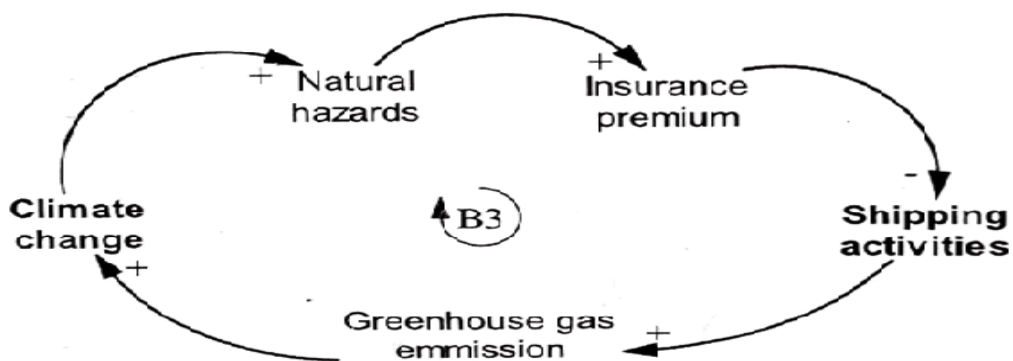


Figure 2. CLD showing the relationships of climate change, natural hazards, insurance, and shipping activities (LOOP)

Most of the natural hazards, includes storm surge, hurricane, typhoon, and tsunami are initiated from the sea. The shipping sector is more exposed to these hazards than other industries. It is responsible to raise insurance premium in shipping business. International maritime organization (IMO) adopted a resolution on CO<sub>2</sub> emissions from ships with a policies and practices related to the reduction of greenhouse gas emission from ships which requests the MEPC to develop a greenhouse gas emission index for ships and guidelines for operations.

Climate change induced ice melting is opening the navigation possibility through the polar region the navigation possibility through the polar region. Navigation through Arctic that increase shipping activities, that is responsible for a part of GHGF emission. Increased temperature is going to convert the ice-covered polar region into a seasonal sea that will create favorable condition for oil exploration.

The huge stock of natural oil and gas reserves in the Arctic are left almost untouched because of adverse environmental conditions. The adverse weather condition in the Arctic is the main obstacle to explore oil and gases of the region.

We find out that climate change is acting positively on ice melting, while effective

oil explorations will increase oil production in the Arctic, which in turn will increase shipping activities. Shipping activities contributing to climate change by GHG emission. The above observation and finding have an overall picture of impacts of climate change on shipping activities.

All other climate events like sea surface temperature rise, sea level rise and climate change policy or emission control regulations will have negative impacts on maritime activities.

When shipping activities increases, maritime industries also increase, on the other hand increase/decrease of shipping activities because of increase /decrease of maritime industries have a weaker relationship because shipping activities could increase on the basis of market demand globally. Climate change will open the door of oil production for some nations. Oil and gas are mainly shipping by maritime transport this will influence existing shipping route which is an impact of climate change. To reach the targeted emission, some nations reduce the use of fossil fuel, especially oil. It will influence all modes of transportation using oil since the oil crises of the early 70s. The issue of global warming led to the introduction of a CO<sub>2</sub> tax in combination with incentives for decentralized electricity generation using renewable resources.

SHOWING IMPACTS OF CLIMATE CHANGE ON MARITIME INDUSTRIES

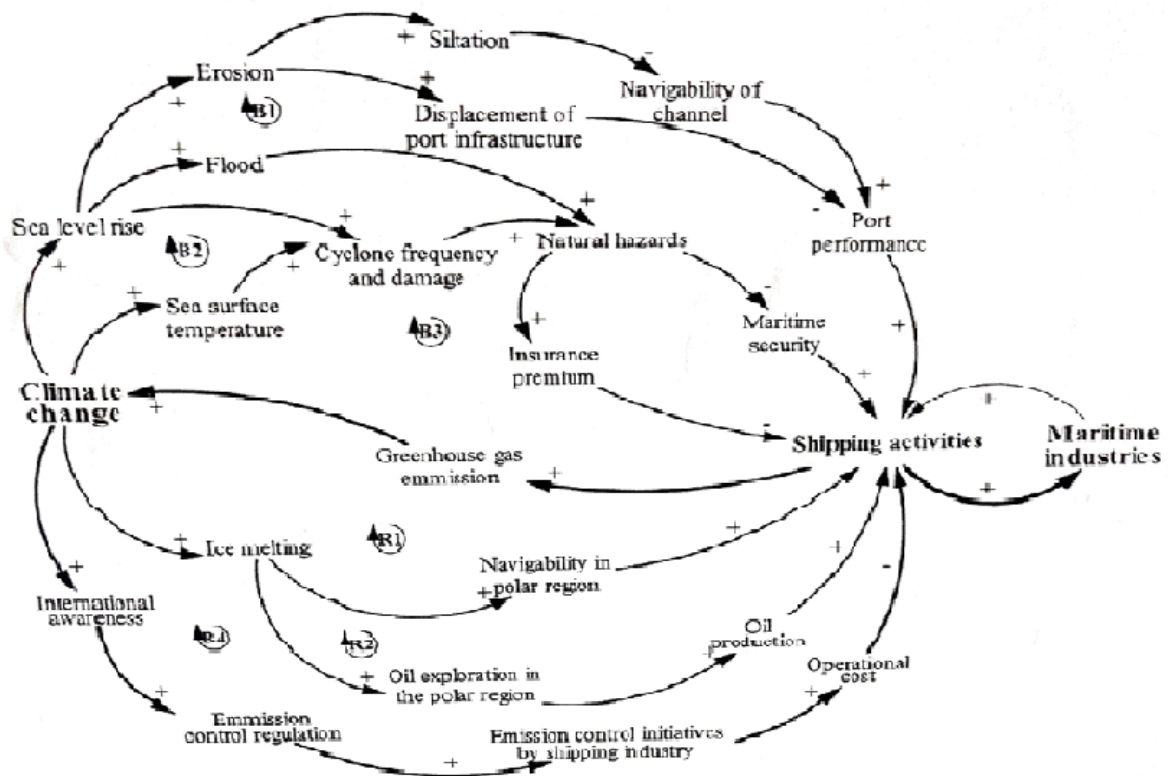


Figure 3: Showing Impacts of Climate Change on Maritime Industries (CLD)

3. Results and Discussion

*Socio- economic impact;* - Climate change induced sea level rise has feasible retardation impacts on socio-economic activities in the country, mostly economic activities located along the coastal belt, a large migration to the coast with serious commercial activities due to the discovery of crude oil and marine environment The destruction of habitat conservation and reserve potential, cultural heritage because of economic reasons due to access to transportation and communication facilities.

The environmental impacts of these outdated technologies have resulted in serious environment degradation ranging from susceptibility of coastal populations movement or transportation, cases of water and air pollution, loss of aquatic life, gas flaring etc. It reduces drastically the size of narrow beaches and compromise value of recreation amenities like hotel and tourism that influx the sea as a result of sea level rise affects the transportation business services. Fisheries resources and decimation of forest because of climate change will mean a decline of economic activities. This will also affect economic

growth and employment rate. This will increase crime rate. The country economy is climate dependent that would cost the nation about 6 to 30% of GDP in the next ten- to – twenty years from now. Considering that the climate change hazards ravaging Nigeria's Southern region transcend common Eco zones and regional boundaries with national and global implications in term of policy response. The execution of those programs offers a framework for undertaking similar activities in places experiencing frequent exposures to extreme climate events.

*Renewable Energy:-* This sector is the most important sector for climate change mitigation. It is important to control greenhouse gases by moving towards renewable energy development. The development of control green house gases by moving towards renewable energy is new to the country with growing interest from investors.

It is necessary to develop innovative financing schemes that will reduce the cost of low- carbon technologies for consumers in addition to making it a profitable project for investors (Dioha and Emodi 2018). The inclusion of crop diversification the adoption of drought tolerant and early maturing varieties of crops and crop cover. The ability of maritime industries and the shipping organization to adjust to climate change to moderate potential changes, to take advantage of opportunities to cope with the consequences, this depends on quality of education assets, information, and revenue. The research recommends greater awareness creation on climate change issues through public participation and technological, policies and programmes aimed at access information for and raising awareness among public policy makers.

There should be access to specific weather information with every warming and forecast technologies will help to develop and readjust coping or adaptation strategies. The general aid should be listed to the radio and television where weather forecasts are usually broadcasted. There are needs for require training to act as educational skilled and information services provision that are necessitates comprehensive capacity building of skilled, trained professionals the government has a role to play in capacity building to achieve these various functions in relation to climate change impact. Introducing an effective public education programme requires the planner to address various deficits in the fields of climate change and its impact as well as transportation role in basic climate change. Climate change education modules on environmental issues, transport issues, health issues should go beyond basic understanding of how the climate system works. The implementation of effective adaptation response strategies requires strengthening specialized climate agencies. To minimize the emission, an improved fuel quality use of energy efficient engines is a task of ship owners to cut down the emission.

### **Conclusion**

Many agencies and committee should be appointed to oversee the planned activities to pursue for the reduction of emissions of greenhouse gases working through IMO. To reduce GHG, the mechanism included GHG emission baseline, to develop GHG emission index for ships and the evaluation of technical, operational, and market-based solutions. The marine environment protection committee (IMEPC) of guideline recognized Co<sub>2</sub> as



the main GHG emitted by ships. Shipping sectors must find out the perfect clean energy for its sustainability. The industry should conduct research to see whether Hyphen is a viable source of energy for its future activities. Growing public concerns on climate change is building international awareness to find out ways to reduce CO<sub>2</sub> from shipping sector. This will increase the cost of operation and maintenance of the sector that will eventually affect transport cost/prices and the economy of the maritime industries. Shipping industry has a great potential to contribute to the reduction of the release of GHG, especially CO<sub>2</sub> emission.

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