Evaluating Maritime Crew Knowledge of Shipping-Related GHG Impacts on the Climate System's Equilibrium

Prepared By
Adham Sayed Mohamed Torky [(1)], Agne Jucyte Cicine [(2)]
[(1)] Arab Academy for Science, Technology and Maritime Transport, Egypt
[(2)] Lithuanian Maritime Academy, AIN Journal Editorial board member

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المستخلص

تهدف هذه الدراسة البحثية إلى تقييم معرفة الضباط والمهندسين البحريين بتأثير انبعاثات غازات الاحتباس الحراري في النقل البحري على توازن النظام المناخي.

تستخدم هذه الدراسة ثلاث طرق لتحليل بياناتها إحصائيًا، وهي اختبار مربع كاي، واختبار ويلكوكسون لعينة واحدة، واختبار فيشر- فريمان- هالتون الدقيق. واستُخدم الاستبيان كأداة رئيسية لجمع البيانات في هذه الدراسة. وشملت العينة ١٠١ ضابطًا ومهندسًا بحريًا.

تشير نتائج الدراسة إلى مدى معرفة المشاركين ووعيهم بأن النقل البحري يساهم بشكل كبير في انبعاثات غازات الاحتباس الحراري، والتي تلعب دورًا رئيسيًا في تغير المناخ.

توضح هذه الدراسة أهمية دمج قضية تغير المناخ في المناهج الدراسية البحرية لمختلف الأكاديميات البحرية، بالإضافة إلى التعاون بين مختلف الجهات المسؤولة، ممثلة بالحكومات والمنظمات الدولية وصناع القرار في المجال البحري، لتعزيز المشاركة المهنية والمجتمعية في التقنيات التي تساعد على الحد من الانبعاثات والتكيف مع تغير المناخ، الذي أصبح قضية دولية.

Abstract:

This research study aims to evaluate marine officers' and engineers' knowledge of the influence of greenhouse gas (GHG) emission in maritime shipping on the balance of the climate system.

This study uses three methods to statistically analyze the study data, which are the Chi-Square Test, the Wilcoxon One-Sample Test, and the Fisher-Freeman-Halton Exact Test. A questionnaire was used as the main method of data collection in this investigation. The sample was available with 101 marine officers and engineers.

The study results indicate the extent of knowledge and awareness among participants that maritime transport contributes significantly to greenhouse gas emissions, which play a major role in climate change.

This study clarifies the importance of integrating the issue of climate change into the maritime curricula of various maritime academies. in addition to cooperation between the various

responsible parties, represented by governments, international organizations, and decision-makers in the maritime field, to promote professional and societal participation in technologies that help mitigate emissions and adapt to climate change, which has become an international issue.

Keywords: Climate system, Greenhouse gas, Maritime shipping, Marine officers and engineers

1. Introduction:

The amount of (GHGs) in the atmosphere has been greatly increased by human activities since around 1750, which has led to an increase in temperature over the last few hundred years. The mean surface air temperature has increased by 1.1°C over pre-industrial levels, indicating that global warming has intensified in recent decades. (GHGs) and other pollutants, such as particulate matter (PM) and ozone precursors (O_3), are released during the extraction and burning of fossil fuels. (Wang et al., 2023)

One of these is maritime shipping, which is the main means of transportation for manufactured goods, food, and raw materials. Transcontinental trade is also facilitated by it. Over 80% of goods traded globally and 70% of the value of international trade are transported by ships of various kinds. (Salihoglu & Bal Besikci, 2021). However, shipping is also a major source of (GHG) emissions, making up two to three percent of global CO_2 emissions. (Bullock et al., 2022; Roy and Chakraborty, 2025).

The purpose of this section is to examine and assess how the emission of (GHGs) in maritime shipping affects the climate system's equilibrium and the International Maritime Organization's response. This is accomplished by means of earlier research.

The primary long-lived greenhouse gases, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and carbon tetrachloride (CCl_4), are all increasing in the atmosphere because of human activities. (Watson et al., n.d.)

The extraction and burning of fossil fuels, as well as changes in land use and the use of halocarbons, are the main ways that humans have seriously disrupted the climate system's energy balance. Methane and nitrous oxide, two potent (GHGs), are also released into the environment by waste treatment and agriculture. (Bruhwiler et al., 2021)

The expansion of economies and populations is a major contributing factor to the rising worldwide demand for energy. They have helped both the overall number of ships engaged in international shipping and the notable expansion of international maritime trade. (Islam Rony et al., 2023) Due to an 18% increase in global trade between 2016 and 2019, shipping fuel consumption rose by 50% between 2012 and 2040. (Lin & Raza, 2020)

Shipping now accounts for 2.89% of global anthropogenic emissions due to industry's reliance on fossil fuels. Ship emissions of greenhouse gases, including sulfur oxides, nitrogen oxides, and particulate matter, pose a major threat to human health and the environment within 400 kilometers of land. (Elashwah 2025 & Ampah et al., 2021)

The shipping industry has several detrimental effects on the marine environment. A few factors contribute to climate change, such as the atmospheric release of greenhouse gases like CO_2 and short-lived climate pollutants like methane and black carbon, NO_x, and SO_x in different marine locations. (Eyring et al., 2010)

The ports sector is one of the maritime sites; port activities are essential to the growth of the economies and job markets of developing countries. (Azarkamand etal. 2020) Because of their complexity and diversity, this industry's operations have a negative impact on the environment. Waste creation, soil contamination, noise pollution, and gas emissions that lead to air pollution are some of the effects. (Diniz et al., 2023)

Port operations are one facet of marine activity; green ports, also known as sustainable ports, are those that

use less energy and produce fewer emissions. (KSIĄŻKIEWICZ, 2020) This can be accomplished with the aid of energy-efficient devices and renewable energy sources like solar or wind power. (Inal, 2023)

Climate change is a danger because of the potential problems it may cause in the future. Climate change may have several detrimental repercussions. The earth's climate is currently changing in a few ways and at a very rapid pace. (Edward 2020)

For instance, there are numerous indications of climate change. (Fahad, 2020):

1- Consequences of the Arctic Ice Crisis: Temperature increases brought on by an increase in greenhouse gases may have detrimental consequences on the environment. The Arctic ice has been melting as a result.
2- Oceanic Impacts: The effects of climate change on the ocean are also noticeable. Large volumes of CO_2 are trapped in oceans, which act as significant "carbon pools," preventing them from entering the upper atmosphere. Rising ocean temperatures and more acidic waters because of increased CO_2 concentrations are already influencing the oceans. At a temperature of 1°C, the consequences of climate change are already causing considerable changes in the oceans, with a critical threshold of 1.5℃ and higher predicted. Coral reefs are expected to decrease by 70–90% at 1.5°C. A 2℃ increase in temperature will cause practically all coral reefs to disappear. It is devastating for more than just the fauna because coral reef fish are the main source of protein for half a billion people.
3- More than other places, polar regions are seeing the consequences of climate change. The northern and southern hemispheres, which are also especially vulnerable to the consequences of global warming, play a major role in regulating the temperature of our planet.
4- Effects on the Pattern Changes in Precipitation: hurricanes, floods, droughts, and precipitation have all become more common during the last 20 years. While some areas receive a lot of precipitation, others endure year-round drought.

The current study employs a questionnaire as part of its approach to increased awareness and knowledge of the impact of (GHG) emissions from maritime shipping on the balance of the climate system.

2. Methods of Analysis:

The knowledge of marine officers and engineers working on commercial ships regarding the effects of (GHG) emissions in maritime shipping on the climate system's equilibrium was the focus of the research problem. The selected methodological approach might be considered a methodical and scientific approach to the research topic. This method makes it easier to incorporate research results into the topic's larger theoretical and methodological framework. (Kothari, 2004)

The features of the research questions and the topic being studied are the main factors that influence the choice of research methodology. As suggested by Denzin and Lincoln (2005), This research paper attempts to provide participants with a comprehensive overview of their views and knowledge about greenhouse gases, including their sources, their impact on climate balance, and strategies for mitigating and adapting to this global phenomenon. It is based on data gathered from maritime professionals at both the managerial and operational levels, with varying degrees of experience. Descriptive statistics and suitable inferential tests are used for this.

2.1 Questionnaires Design:

The questionnaire was designed as a research tool to evaluate knowledge of the impact of greenhouse gases on the Earth's climate system through several participants working in the maritime sector on various commercial ships.

The questionnaire was multidimensional; each item was examined separately rather than as a single composite scale. Consequently, internal consistency reliability measures such as Cronbach’s alpha were not deemed appropriate. Instead, the analysis relied on descriptive statistics and suitable inferential tests to examine differences and associations among variables.

The questionnaire was revised several times to make sure it followed pilot study rules, reviewed data, filled out options, and utilized appropriate language and vocabulary, to ensure the accuracy and security of the survey questions' wording and scientific design, as well as the extent to which the problem and objectives of the study have been handled. Along with the review by industry experts, additional phrases were added, and some were recast to improve the study tool and the use of the five-level Likert scale.

The researcher distributed hard copies of the questionnaires to those who are on vacation to renew their certificates at the Arab Academy for Science, Technology, and Maritime Transport, and the Google Drive link was sent directly to officers and engineers via social media, totaling 101 people.

2.2 Sampling Procedure:

The researchers were able to select marine officers and engineers from the Arab Academy for Science, Technology, and Maritime Transport who had experience sailing on a variety of ships by using stratified sampling.

Every questionnaire that was returned was examined to make sure it was legitimate and free of stray signs and other damage. After receiving 101 accurate questionnaires, the information was input into an Excel spreadsheet.

2.3 Data Collection:

A standardized questionnaire was employed to gather the data. The previously described tool was specifically designed to collect information about the demographic characteristics of the respondents and their awareness of the impact of (GHG) emissions.

All information collected is confidential and will not be shared except with the permission of the participants or as required by law.

2.4 Research Limitations:

Any scientific research has limitations that can prevent generalization of the results. This research faced a limitation regarding the place, as this research targeted the officers and engineers in Egypt. The researcher suggests conducting future studies of different nationalities too if the same results are achieved.

2.5 Data Analysis:

The data that was gathered underwent analysis through the utilization of the Statistical Package for the Social Sciences (SPSS), specifically version 27. The following analytical techniques were used:

- The sample was described, and participants' opinions were summarized using descriptive statistics: frequencies, percentages, means, medians, and standard deviations.
- For ordinal-scale items, the Wilcoxon One-Sample Test was used to determine whether respondents' perceptions deviated considerably from a postulated reference value.
- For categorical variables with tiny, predicted cell counts, the Fisher-Freeman-Halton Exact Test was utilized to investigate variations in answers based on years of maritime sector experience.
- When test assumptions were satisfied, the Pearson Chi-Square Test was used to evaluate relationships between categorical variables and years of marine experience.
- The data were displayed in tables and figures for interpretation, and all statistical tests were performed at a significant level of $p < 0.05$.

3. Results:

3.1 Analysis of Questionnaire Results:

3.1.1 General awareness:

3.1.1.1 Awareness of the Concept of (GHGs):

The study sample's answers on their knowledge with the phrase (GHGs) are displayed in Table 1. using the Wilcoxon one-sample test results and descriptive statistics.

Table (1) Awareness of the Concept of Greenhouse Gases

Are you familiar with the term greenhouse gases (GHGs)?	Frequency	Percent	Mean ± SD	Median	Wilcoxon One-Sample Test	
					Standardized Test Statistic	Sig.
Very familiar	28	27.72%	3.52± 1.23	4	3.805	0.000
Familiar	23	22.77%				
Somewhat familiar	31	30.69%				
Not very familiar	11	10.89%				
Not familiar at all	8	7.92%				
Total	101	100.00%				

Table (1) shows the results of the Wilcoxon one-sample test, indicating that the observed degree of familiarity and the anticipated neutral or reference value differ significantly. that rather than being random or marginal, the respondents' understanding of greenhouse gases is significant and statistically significant.

Overall, the research sample's comprehension of greenhouse gases is adequate, offering a solid foundation for examining their awareness of how they affect the climate system.

3.1.1.2 Identification of Greenhouse Gases:

Table (2) shows results of study sample responses about gases that are considered greenhouse gases, with the results of the Fisher–Freeman–Halton exact test.

Table (2) Identification of Greenhouse Gases

Which of the following gases do you think are greenhouse gases? (n=28)	Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
	Less than 5 years	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Count	16	24	22	62			
Carbon dioxide (CO2)					1	0.44	0.81
%	57.14%	64.86%	61.11%	61.39%			

Which of the following gases do you think are greenhouse gases? (n=28)		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 years	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Count		10	10	14	34			
Methane (CH4)						2	1.25	0.58
%		35.71%	27.03%	38.89%	33.66%			
Oxygen (O2)	Count	3	3	6	12	5	1.29	0.55
	%	10.71%	8.11%	16.67%	11.88%			
Ozone (O3)	Count	1	3	10	14	4	8.33	0.01
	%	3.57%	8.11%	27.78%	13.86%			
Count		7	5	5	17			
Water vapor (H2O)						3	1.78	0.40
%		25.00%	13.51%	13.89%	16.83%			

The results in table (2) indicate that awareness of carbon dioxide as a greenhouse gas is relatively high and consistent across years of experience in the marine field, while knowledge of other gases remains limited.

3.1.1.3 The perceived gravity of increasing greenhouse gas concentrations and their effects on the planet's climate system:

Table (3) shows results of study sample responses regarding the dangers of rising greenhouse gas concentrations and their impact on the climate, according to years of experience, using the Pearson chi-square test to examine group differences.

Table (3) The perceived gravity of increasing greenhouse gas concentrations

How serious do you think the problem of rising greenhouse gas concentrations is for Earth's climate system?		Years in the Maritime Industry			Total	Pearson Chi-Square Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)		Test Statistic	Sig.
Extremely serious	Count	14	7	13	34	8.17	0.09
	%	50.00%	18.92%	36.11%	33.66%		
Moderately serious	Count	13	25	18	56		
	%	46.43%	67.57%	50.00%	55.45%		

How serious do you think the problem of rising greenhouse gas concentrations is for Earth's climate system?		Years in the Maritime Industry			Total	Pearson Chi-Square Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)		Test Statistic	Sig.
Not serious	Count	1	5	5	11		
	%	3.57%	13.51%	13.89%	10.89%		

The results indicate that most respondents across all experience groups perceive the problem as either moderately serious or extremely serious. Despite these descriptive variations, the Pearson chi-square test indicates that the association between years of maritime experience and perceived seriousness is not statistically significant ($\chi^2 = 8.17$, $p = 0.09$). Accordingly, differences in perceptions across experience groups do not reach the conventional level of statistical significance.

Overall, the findings suggest a broadly shared recognition among maritime professionals of the seriousness of rising greenhouse gas concentrations and their potential impact on the Earth's climate system, irrespective of years of experience in the industry.

3.1.2 Causes and Sources:

3.1.2.1 Perceptions of Major Sectoral Contributors to Greenhouse Gas Emissions by Years of Maritime Experience:

Table (4) presents respondents' perceptions of the sectors that contribute most to greenhouse gas emissions, disaggregated by years of experience in the maritime industry, along with the results of the Fisher–Freeman–Halton exact test.

Table (4) Sectoral Contributors to Greenhouse Gas Emissions

Which sectors contribute most to greenhouse gas emissions?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Maritime industry	Count	12	11	18	41	1	3.19	0.20
	%	42.86%	29.73%	50.00%	40.59%			
Energy production	Count	10	4	11	25	3	6.63	0.04
	%	35.71%	10.81%	30.56%	24.75%			
Industry and manufacturing in general	Count	10	16	15	41	1	0.42	0.85
	%	35.71%	43.24%	41.67%	40.59%			

Which sectors contribute most to greenhouse gas emissions?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Deforestation/land use change	Count	5	17	9	31	2	6.46	0.04
	%	17.86%	45.95%	25.00%	30.69%			

The findings show that the maritime industry and manufacturing in general are jointly ranked as the most frequently identified contributors.

Overall, these results reveal both commonalities and experience-related differences in perceptions of sectoral greenhouse gas contributors. While industry, manufacturing, and maritime activities are widely recognized as significant sources of emissions, awareness of the roles played by energy production and deforestation varies significantly with years of maritime experience.

3.1.2.2 Perceptions of Human Activities as the Primary Driver of Increased Greenhouse Gas Concentrations:

Table (5) presents respondents' views on whether human activities are the main cause of increased greenhouse gas concentrations, along with descriptive statistics and the results of the Wilcoxon one-sample test.

Table (5) Perceived role of human activities in Greenhouse Gas

Do you think human activities are the main cause of increased GHG concentrations?					Wilcoxon One-Sample Test	
	Frequency	Percent	Mean ± SD	Median		
					Standardized Test Statistic	Sig.
Extremely relevant	15	14.85%				
Very relevant	18	17.82%				
Somewhat relevant	45	44.55%				
			3.18± 1.09	3	1.687	0.092
Slightly relevant	16	15.84%				
Not relevant at all	7	6.93%				
Total	101	100.00%				

The results indicate a moderate level of agreement with the anthropogenic explanation of rising greenhouse gas concentrations. The overall mean score of 3.18 ± 1.09, with a median value of 3, suggests a central tendency toward a moderate level of agreement rather than strong conviction.

Overall, the results here indicate that although most participants agreed that human activity plays an influential role in increasing greenhouse gas concentrations, some still believe that this is not the strongest reason.

3.1.3 Effects on the climate system:

3.1.3.1 Perceived Effects of Climate Change Linked to Increased Greenhouse Gas Levels:

Table (6) The results of the study sample's responses regarding the most prominent negative effects of increased greenhouse gas levels are categorized according to the participants' years of experience. with the results of the Fisher–Freeman–Halton exact test.

Table (6) Climate Change associated with higher Greenhouse Gas levels

Which climate change do you associate with higher GHG levels?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Global temperature rise	Count	19	21	13	53	1	6.71	0.03
	%	67.86%	56.76%	36.11%	52.48%			
Melting glaciers and polar ice caps	Count	10	10	13	33	3	1.00	0.64
	%	35.71%	27.03%	37.14%	33.00%			
Sea level rise	Count	14	13	20	47	2	3.23	0.20
	%	50.00%	35.14%	55.56%	46.53%			
Ocean acidification	Count	3	2	11	16	4	8.66	0.01
	%	10.71%	5.41%	30.56%	15.84%			
Changes in rainfall patterns	Count	5	2	3	10	5	2.68	0.26
	%	17.86%	5.41%	8.33%	9.90%			

The findings indicate that global temperature rise is the most frequently associated climate change. Overall, the results suggest that respondents most readily associate higher greenhouse gas levels with more visible and widely publicized climate impacts, such as global temperature rise and sea level rise. In contrast, more complex or indirect consequences, particularly ocean acidification and altered rainfall patterns, are less frequently recognized, with significant differences emerging only among more experienced maritime professionals.

3.1.3.2 The direct effect of greenhouse gas emissions on the climate system's stability:

Table (7) Results of the study sample's responses regarding participants' opinions that greenhouse gases affect climate balance, according to years of experience using the Pearson chi-square test.

Table (7) The direct effect of greenhouse gas emissions on the climate system's

How much do you agree with the statement: Greenhouse gas emissions have a direct impact on the stability of Earth's climate system.		Years in the Maritime Industry			Total	Pearson Chi-Square Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)		Test Statistic	Sig.
Strongly agree	Count	7	11	8	26	8.46	0.39
	%	25.00%	29.73%	22.22%	25.74%		
Agree	Count	9	15	6	30		
	%	32.14%	40.54%	16.67%	29.70%		
Neutral	Count	7	7	13	27		
	%	25.00%	18.92%	36.11%	26.73%		
Disagree	Count	4	3	6	13		
	%	14.29%	8.11%	16.67%	12.87%		
Strongly disagree	Count	1	1	3	5		
	%	3.57%	2.70%	8.33%	4.95%		

The results indicate a general trend among marine officers and engineers to agree on this noticeable effect of these gases. Despite these descriptive differences, the Pearson chi-square test indicates that the association between years of maritime experience and agreement with the statement is not statistically significant ($\chi^2 = 8.46$, $p = 0.39$).

Overall, the results show that there is an understanding, knowledge, and awareness of the relationship between greenhouse gases, of which the marine industry is one source, and climate change.

3.1.4 Adaptation and mitigation:

3.1.4.1 Perceived Efficiency of Greenhouse Gas Emission Reduction Measures:

Table (8) The results show the most effective measures to reduce greenhouse gas emissions. with the results of the Fisher–Freeman–Halton exact test.

Table (8) Actions to reduce Greenhouse Gas emission

Which actions do believe are most effective in reducing greenhouse gas emissions?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 year (n=28)	5 : 10 years (n= 37)	More than 10 years (n=36)			Test Statistic	Sig.
Switching to renewable energy	Count	14	21	24	59	1	1.87	0.39
	%	50.00%	56.76%	66.67%	58.42%			

Which actions do believe are most effective in reducing greenhouse gas emissions?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 year (n=28)	5 : 10 years (n= 37)	More than 10 years (n=36)			Test Statistic	Sig.
Improving energy efficiency	Count	13	5	6	24	3	10.03	0.01
	%	46.43%	13.51%	16.67%	23.76%			
Promoting public transportation	Count	4	6	12	22	4	4.07	0.14
	%	14.29%	16.22%	33.33%	21.78%			
Reforestation and forest conservation	Count	7	1	4	12	5	7.20	0.02
	%	25.00%	2.70%	11.11%	11.88%			
Reducing waste and promoting recycling	Count	8	7	11	26	2	1.51	0.49
	%	28.57%	18.92%	30.56%	25.74%			

The survey results indicate that many participants with varying years of experience believe that relying on renewable energy is the most effective measure for mitigating or adapting to climate change. However, another group holds a different view, promoting public transportation, reforestation, and forest conservation and promoting recycling, reflecting differences in priorities.

3.1.4.2 The parties responsible for taking the lead in addressing the phenomenon of greenhouse gas emissions:

Table (9) shows the participants' views on the entities responsible for adopting a set of strict measures to reduce these emissions, with the results of the Fisher–Freeman–Halton exact test.

Table (9) Responsibility for leading GHG mitigation efforts

In your opinion, who should take the lead in addressing greenhouse gas emission?		Years in the Maritime Industry			Total	Rank	Fisher-Freeman-Halton Exact Test	
		Less than 5 years (n=28)	5-10 years (n=37)	More than 10 years (n=36)			Test Statistic	Sig.
Governments	Count	16	19	11	46	2	5.27	0.07
	%	57.14%	51.35%	30.56%	45.54%			
International organizations (eg, UN)	Count	15	13	24	52	1	7.28	0.03
	%	53.57%	35.14%	66.67%	51.49%			
Businesses / industries	Count	8	9	10	27	3	0.24	0.92
	%	28.57%	24.32%	27.78%	26.73%			
Educational institutions	Count	6	0	7	13	4	10.51	0.00
	%	21.43%	0.00%	19.44%	12.87%			

In general, the participants were Marine officers and engineers, and therefore the prevailing view was that the responsibility lay with international organizations (e.g., the UN).

4- Discussion:

The main question of research is whether there is knowledge of the impact of greenhouse gases on climate systems. After analyzing the results, it can be concluded that, as in other similar studies (Eyring et al., 2010), (Azarkamand etal. 2020) and (Diniz et al., 2023) rising greenhouse gas concentrations and their potential impact on the Earth's climate remain a major concern.

The maritime shipping sector is viewed as a contributor to greenhouse gas emissions, and one of the points that must be emphasized, and which the results showed, is that knowledge of these gases and also their direct impact on the climate system is high, but there is a disparity in the level of awareness of the sources of these gases and understanding of their repercussions.

Although many of the observed differences were not statistically significant, the results confirm the close relationship between the years of experience of the sailors participating in the survey and their awareness of the effects of these gases, as knowledge increases with experience.

In view of the overall results, shipping decision-makers should consider the importance of increasing attention to educating maritime officers in the shipping sector about these gases and the plans of the International Maritime Organization and other bodies, such as national governments, to mitigate and adapt to reduce the resulting effects.

The above suggestions aim to close known gaps in knowledge and create a climate that supports proactive behavior and policymaking that recognizes the urgent need to reduce these emissions.

One of the main limitations of the study is the research faced a limitation regarding the place, as this research targeted the officers and engineers in Egypt. As a result, it would be ideal to increase the sample size to include individuals of other nationalities.

5. Conclusion and Recommendations:

The results obtained in this study can be relied upon to assess the extent of knowledge about the impact of greenhouse gases resulting from the marine industry on the balance of the climate system.

This study recommends cooperation between governments, shipping companies, and international organizations, as well as increased funding for scientific research related to technologies for reducing these emissions.

Also, reviewing the environmental policies issued by the International Maritime Organization and encouraging the use of renewable energy on board ships and in ports to become green ports.

the necessity of focused environmental education and training for the maritime sector, with a stronger focus on the entire range of greenhouse gases and how each contributes to climate change.

The researcher recommends doing further research on other nations from various maritime colleges and institutes to determine whether the same outcomes would be obtained, as this study was limited to Egypt.

References:

- Azarkamand, S., Wooldridge, C., & Darbra, R. M. (2020). Review of initiatives and methodologies to reduce CO2 emissions and climate change effects in ports. International journal of environmental research and public health, 17(11), 3858. https://doi.org/10.3390/ijerph17113858

- Ampah, J. D., Yusuf, A. A. A., Afrane, S., Jin, C., & Liu, H. (2021). Reviewing two decades of cleaner alternative marine fuels: Towards IMO's decarbonization of the maritime transport sector. Journal of Cleaner Production, 320. https://doi.org/10.1016/j.jclepro.2021.128871

- Bullock, S., Mason, J., Larkin, A. (2022). The urgent case for stronger climate targets for international shipping. Climate Policy, vol. 22, no. 3, pp. 301–309. https://doi.org/10.1080/14693062.2021.1991876

- Bruhwiler, L., Basu, S., Butler, J. H., Chatterjee, A., Dlugokencky, E., Kenney, M. A., McComiskey, A., Montzka, S. A., & Stanitski, D. (2021). Observations of greenhouse gases as climate indicators. Climatic Change, 165(1–2). https://doi.org/10.1007/s10584-021-03001-7

- Roy, A.; Chakraborty, M. A review of ship emissions impacts on environmental, health, societal impacts and IMO's mitigation policies. Reg. Stud. Mar. Sci. 2025, 81, 103964.

- Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. The Sage handbook of qualitative research, 3, 1-32.

- Diniz, N. V., Cunha, D. R., Porte, M. de S., & Oliveira, C. B. M. (2023). Disclosure of the sustainable development goals in the maritime industry and port sector. Revista de Gestão e Secretariado (Management and Administrative Professional Review), 14(5), 8129–8149. https://doi.org/10.7769/gesec.v14i5.2185

- Elhussieny, Mohamed. "Maritime Port Evolution: Balancing Operational Excellence with Zero-Emission Requirements in the Context of IMO 2050 Objectives." AIN Journal 50, no. 2 (July 1, 2025). https://doi.org/10.59660/50709.

- Eyring, V., Isaksen, I. S. A., Berntsen, T., Collins, W. J., Corbett, J. J., Endresen, O., Grainger, R. G., Moldanova, J., Schlager, H., & Stevenson, D. S. (2010). Transport impacts on atmosphere and climate: Shipping. Atmospheric Environment, 44(37), 4735–4771. https://doi.org/10.1016/j.atmosenv.2009.04.059

- Edward, l. u. o. c. (2020). Climate change -the causes, influence and conceptual -the causes, influence and conceptual management. August.

- Fujimori, S., Hasegawa, T., Takahashi, K., Dai, H., Liu, J. Y., Ohashi, H., Xie, Y., Zhang, Y., Matsui, T., & Hijioka, Y. (2020). Measuring the sustainable development implications of.

- Islam Rony, Z., Mofijur, M., Hasan, M. M., Rasul, M. G., Jahirul, M. I., Forruque Ahmed, S., Kalam, M. A., Anjum Badruddin, I., Yunus Khan, T. M., & Show, P. L. (2023). Alternative fuels to reduce greenhouse gas emissions from marine transport and promote UN sustainable development goals. Fuel, 338. https://doi.org/10.1016/j.fuel.2022.127220

- Inal, O. B. (2023). and Academic Research An Overview of Green Ports and Sustainable Development Goals. 409–413.

- Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.

- KSIĄŻKIEWICZ, D. (2020). Clean air policy in european marine ports. Scientific Papers of Silesian University of Technology. Organization and Management Series, 2020(149), 371–381. https://doi.org/10.29119/1641-3466.2020.149.32

- Lin, B., & Raza, M. Y. (2020). Analysis of energy security indicators and CO2 emissions. A case from a developing economy. Energy, 200. https://doi.org/10.1016/j.energy.2020.117575

- Roy, A., & Chakraborty, M. (2025). A review of ship emissions impacts on environmental, health, societal impacts and IMO's mitigation policies. Regional Studies in Marine Science, vol. 81, article no. 103964. https://doi.org/10.1016/J.RSMA.2024.103964

- Salihoglu, E. & Bal Beşikçi, E., 2021. The use of Functional Resonance Analysis Method (FRAM) in a maritime accident: A case study of Prestige. Ocean Engineering, 219, p.108223.

- Wang, P., Yang, Y., Xue, D., Ren, L., Tang, J., Leung, L. R., & Liao, H. (2023). Aerosols overtake greenhouse gases causing a warmer climate and more weather extremes toward carbon neutrality. Nature Communications, 14(1). https://doi.org/10.1038/s41467-023-42891-2

- Watson, R. T., Filho, L. G. M., Sanhueza, E., Janetos, A., Fraser'^; P. J., Fung, I. J., Khalil, M. A. K., Manning, M, Mcculloch,; A, & Mitra, A P. (n.d.). Al Greenhouse Gases: Sources and Sinks