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"MARLOG 12"

Conference Proceedings

Sustainable & Innovative Technologies
Towards a Resilient Future
12 - 14 March, 2023 Alexandria - EGYPT

2023 12 MarLog

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Prof. Akram Soliman Elselmy
Head, Conference Organizing Committee
Professor of Port Planning and Coastal Engineering, AASTMT

Proceedings of

The International Maritime Transport and Logistics Conference (Marlog 12)

Alexandria, Egypt
12th-14th March 2023

Arab Academy

for Science, Technology & Maritime Transport

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A publication of the International Maritime Transport and Logistics Conference
Arab Academy for Science, Technology and Maritime Transport
ISSN (Print): 2682-3764
ISSN (Electronic): 2682-3756
ISBN: 978-977-85808-6-0

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Preface

To continue our successful path with the conference's 12th edition, the International Maritime Transport and Logistics Conference organizing committee and I are proud and thrilled to welcome our eminent guests.

By its previous iterations, the MARLOG conference was able to distinguish itself as more than just an annual event and a renowned gathering that is highly anticipated by many. Distinguished maritime and engineering specialists from renowned port authorities, esteemed colleges, and well-known enterprises from all over the world congregate under one roof each year thanks to this significant reputation.

MARLOG 12 Conference Proceedings contains 28 research papers, 24 of them were presented in the conference technical program and 5 are submitted only in the conference proceedings. This year, 33 research papers were submitted to MARLOG 12 from more than 10 different countries around the world, and according to the full paper submitted, the double-blind peer review adapted by the conference and the Technical committee thorough review, 28 research papers were accepted for the conference proceedings.

I would like to extend my gratitude to everyone who helped make MARLOG 12 possible as I finish up this welcome message. AASTMT President Prof. Ismail Abdel Ghafar Ismail Farag, the conference chairman, and all sponsors, partners, and co-organizers are to be thanked first. The members of the organizing committee, the technical committee, the reviewers, and our staff of organizers are also due of praise for their unwavering dedication, support, and ability to make this event happen.

We hope that you have enjoyed your time at the conference and that you managed to gain fruitful and valuable information.

Prof. Akram Soliman Elselmy
Editor-in-Chief

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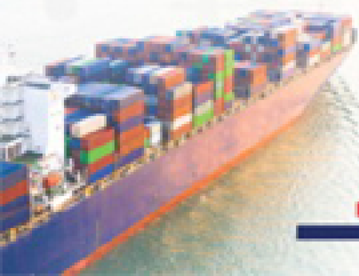

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Supply Chain Resilience Strategies and its Role in Enhancing Competitiveness in the Maritime Transport and Logistics

The Era of Clusters for Economic Growth and Industrial Change, Egypt Case.

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Abstract:

The Arab Republic of Egypt witnessed an industrial development in the nineteenth century while at the beginning of the twenty-first century, Egypt began another phase characterized by the development of the Egyptian industry, raising the competitiveness of Egyptian manufacturing within the framework of an integrated program that contributes to raising exports to effectively join the global economy.

The industrial sector in the Egyptian state represents an advanced rank in the national economy. It comes at the forefront of the economic sectors in terms of its contribution to the GDP, with a rate of 18% in the GDP. In addition, the industrial sector has many relationships with many services and commercial sectors, it also has a role in developing foreign trade and revitalizing the balance of payments.

The paper suggests that in order to maximize the economic return of the industrial sector, the planning of industrial zones should be designed for cluster building.

Many authors have agreed that clusters and agglomerations are the best way to achieve industrial growth. This paper seeks to demonstrate the importance of clusters for many countries and helps to clarify different policies and strategies that could help the Egyptian government build a view that enables the decision-makers to choose the best way that could help economic development. The paper's main finding is that 93 targeted clusters for the Egyptian industry are classified by technological intensity: Medium-high and high technology, Medium technology, and Low technology.

Keywords: Cluster, Industry, Economic

1. Introduction:

There is clear evidence that the quality of the industrial sector and diversification is a key to improving productivity, and accordingly economic growth. The precedent of manufacturing in the 18th and 19th centuries shifted the structure of production in Europe and the USA. Manufacturing was the power for more economic achievement, similarly to what happened in East Asia. Manufacturing makes strong ties with different sectors in the economy which increases demand for more skills, inputs, transportation, and storage. It means that the improvement of the industrial sector enhances growth through different activities. Therefore, most literature found that the source of innovation and technological development was the industrial sector which makes different sectors more productive. Many countries have an enormous share in the total world manufacturing. These economies have adopted different policies and strategies to improve their position on the industrial map. The improvement of this sector reflects the growth of the total economy. Table 1 demonstrates the contributions of these economies in 2019 to the total world industry.

Table (1): Share of the Higher Industrial Countries in the Total World Industry in 2019.

Country	*Percentage of Total World Manufacturing*
China	28.7%
USA	16.8%
Japan	7.5%
Germany	5.3%
India	3.1%
South Korea	3.0%
Italy	2.1%
France	1.9%
UK	1.9%

Source: (IDSC, June 2022)

In fact, a strategy of concentration is more likely to produce fast growth for the largest number of people.

Lin & Monga, 2017 and Booth, et al., 2018 found that the common mistake causing so many failures of industrial zones around the world is to allow such zones to be occupied randomly or to achieve secondary policy objectives so that the learning benefits of agglomeration are missing.

In 2020, the world investment report pointed out that, investors' goals shift to promote strong diversified industrial clusters and enhance cooperatives between SMEs.

Cluster structures are different from old local production systems because they bring and support collaboration between firms and R&D centers such as universities and laboratories. This brought the scientific and industrial units and enabled them to work together as a single unit. Linking local units to the network of formal and informal interactions facilitates joint research and development, exchange of knowledge and information, exchange of modern technology, and spreading of intensive innovation (Kowalski, 2014).

Large companies are leading clusters in the US, Japan, Vietnam, and China, whereas both the EU and South Korea where the SMEs have the focus in clusters (Hollanders, et al., 2020).

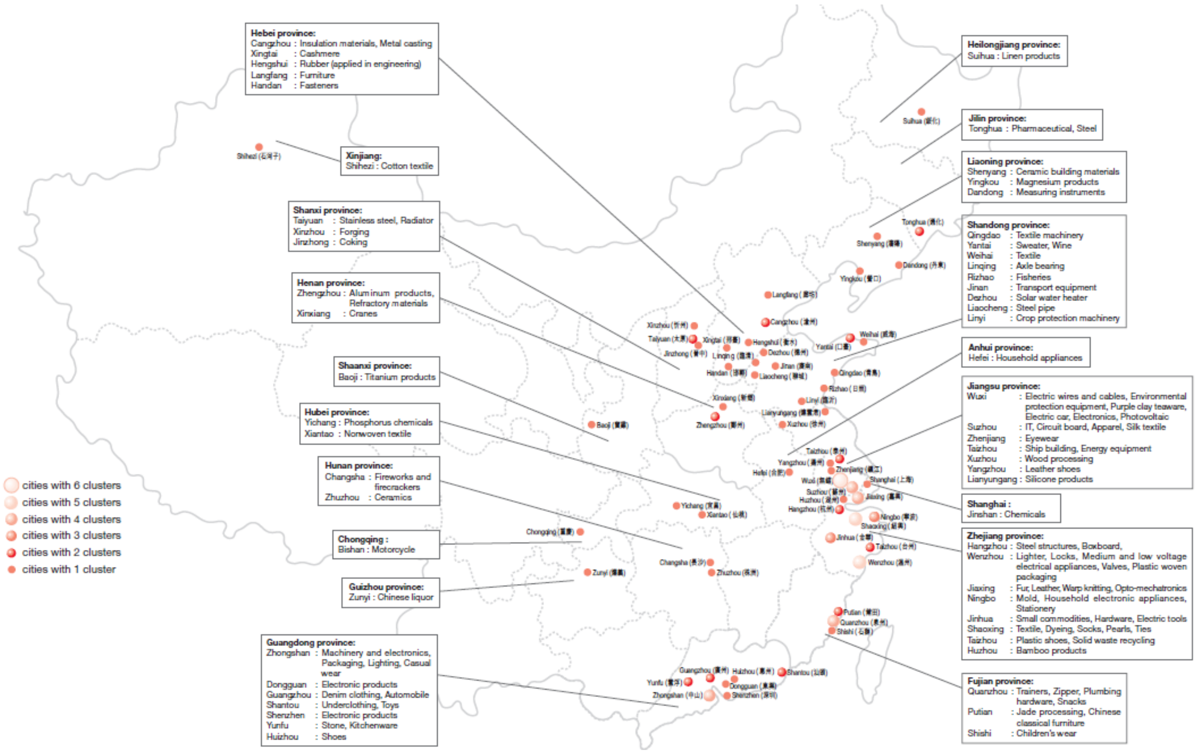
The most recent research by Ketels and Protsiv (2020), using comprehensive data from the European Cluster Observatory demonstrated that the presence of strong clusters is a main driver of wealth in Europe.

2. Literature review

3.1 ***Most Developed and Emerging Countries have Given more Attention to Promoting Clusters*****:** In France, the UK, and the USA 75–95 % of the industry is clustered or concentrated relative to overall economic activity (World Bank, 2009). In **Europe,** there are currently 2950 clusters, accounting for 61.8 million jobs. Moreover, the productivity of companies that are part of clusters is 25% higher than average productivity (ECCP report, 2020). Examples include the National Clusters Platform (Austria), Support Programme Cooperation (Czech Republic), Innovation Clusters Saxony (Germany), Aviation Cluster (Hamburg), Competitiveness Clusters (Portugal), Support Industrial Clusters (Slovakia), Catalisti Spearhead Cluster (Flanders) (ECCP, 2021),

Technology Cluster Initiatives (Canada), The Innovative Cluster Cities Program (South Korea), The Regional Cluster Program (Sweden), Cluster Development Program (Kazakhstan), Chemical Industry Clusters (Chemelot, Netherlands), Operational Programme (Greece), Interaction on Innovation (Denmark), Supported Clustering (Romanian) (Florio, M., et al, 2016). In China, by the year 2001, more than 800 industrial clusters were focusing on 175 industrial sectors (XU, S., 2011).
Figure 1 illustrates the top 100 industrial clusters in China.

Figure (1): Top 100 Industrial Cluster in China.



Compiled by Li & Fung Research Centre

3.2 Intentionally or Organically Formed Clusters?

While building a dynamic cluster from scratch is a more difficult task than strengthening an existing one, intentional clusters could be built by using different strategies and policies. For example, in South Africa, the networking of firms in 15 sectors has been promoted by the Department of Trade and Industry (including motor vehicles, mining equipment, textiles and clothing, the chemical industry, farming and food, and tourism).

In 2007, the government of Kazakhstan launched the cluster development program to support and enhance the total production output of clusters. After 7 years, this program produced more than 400 new products not previously produced in Kazakhstan (ADB, 2018).

In the beginning, the telecommunications industry in China was dominated by foreign companies because the technical levels of Chinese companies were less than those of overseas ones. Also, there was no standard in China at the beginning. So, Chinese companies paid to get the know-how (Fan, 2011). The companies in Huaqiangbei Zone recognized that there was an increased demand for mobile phones in the local economy. Therefore, many Chinese companies in the Zone tried to manufacture their mobile phone products. Between 1998 and 2008, to operate the telecommunications business, the government approved and licensed China's first and largest state-owned company, China Mobile. China Mobile finances Coolpad (Shenzhen), ZTE (Shenzhen), and OPPO (Ai & Wu, 2016).

When the government of Singapore announced its intention to become a biomedical sciences hub, the country did not have any competitive advantages to be attractive in this sector. In the past, Singapore often relied on attracting FDI and supporting them to get the technologies and know-how (Wong, 2001). For example, the advantage of Singapore being the leading IT and electronics manufacturer in the world came from these global MNCs which supported the country before (Wong, 2002). The same strategy was adopted in the biomedical sciences sector. In 2006, the BMS cluster as a whole had an output of $23 billion, with an average annual growth rate of 17.9% since 1980 (Wong, et al, 2010).

3.3 Building Potential Clusters:

a) The first step to identifying potential clusters is to understand the capabilities of current manufacturers in the economy and the relationship between them vertically and horizontally and how these capabilities could be utilized in the larger production systems. After that, identify proximity points between these firms. Economic and industry experts could start to attract those firms which are connected to each other based on their previous knowledge. Then gaps in the system are determined and used to upgrade or attract current or new firms (Doeringer, et al., 1995).

b) Attract knowledge centers, such as universities, and R&D centers from the local economy, either by building new institutions or re-building the present, to emphasize and support the cluster's growth (Wong, et al, 2010).

c) If a large percentage of investment comes from the local economy, this will reduce the knowledge and technology transfers. Therefore, the gaps in the first and second points should be identified, and then foreign players be attracted to the cluster; either knowledge and manufacturing firms or supporting services which will form the knowledge and technology base of the cluster. This could be through incentives and plans which will attract firms into the cluster and encourage those already existing to upgrade their knowledge intensity (Wong, et al, 2010).

3.4 Structure of a cluster:

a) The Steering Committee or cluster board:

The Steering Committee comprises the main stakeholders (e.g. ministries, industrial organizations, promotion agencies, universities, financing institutions, and R&D centers) which have a direct impact on the cluster development and could offer valuable support to them. The Committee/board in most cases is responsible for promoting and launching the project, setting regulations, brokering agreements between agencies and ministries, encouraging supporting initiatives, designing strategic goals, and providing incentives. Make sure that the cluster has developed a long-term strategy to support the economic growth of the country.

b) Cluster Coordinator: This tends to be an expert who has good knowledge of the industry on which the cluster concentrates. Of the most important responsibilities, they could build relationships between cluster members through appropriate communications and arranging discussions between them. In some cases, they may also provide services (e.g., consulting, training, certifications issue, and setting conferences) (Weisert, et al., 2013), enhance connections that support knowledge transfer between research centers and industry and provide strategic direction for cluster members to spread their activities e.g., digitalization, and collaborative activities (Alexandre et al, 2012).

c) The Executive Team: is responsible for daily decision-making related to cluster processes and all management activities (Weisert, et al., 2013), ensuring all procedures are aligned with the policy and regulations enacted (Alexandre et al, 2012).

d) Cluster Development Agents: CDAs perform the role of impartial brokers who provide guidance and support to the cluster (Weisert, et al., 2013). They gather information from a wide range of internal stakeholders and foreign markets and map out these potential markets. They also gather information about new supply chains and provide advice on improving the processes. They provide support for mapping out local assets and identifying new trends, which will contribute to building cluster members' capabilities, and showcase events for cluster members to present their capabilities to MNCs or government entities (Alexandre, et al, 2012).

3.5 *The Importance of Collaboration and Presence of Different Entities inside each Cluster*: The presence of different entities in the same cluster is very important but what is most important is the collaboration between them to get the most benefits.

a) Bangalore is considered one of the most successful clusters in India and the world in the IT sector. Most of its success comes from the relationship between multinational and local firms and research, educational, and training centers. The cluster is very famous for intensive connection between their members (Session, 1999). The Central Machine Tools Institute provides technical support, testing facilities, designs and modifies machine tools on request, and researches and develops CNC technologies (K. Nadvi, 1995).

b) In Spain, the advanced materials cluster "MAV" acted as a facilitator between individual protection equipment manufacturers from Spain and the suppliers of raw materials from France, which allowed the Spanish manufacturers to increase their production and diversification (Kamp, et al, 2020).

c) In Japan, there are three main organizations supporting the development of each cluster (i.e., Cluster Promotion Organizations (CPOs), Cluster Project Promotion Organization (CPO), and The Japan External Trade Organization (JETRO)), which complement each other and are responsible for: managing every cluster, providing information, calling for seminars, connecting businesses, advertising, counseling, educational centers collaboration and promotion for each cluster (Fujita & Hill, 2007).

d) In China, Wenzhou University played a pivotal role in enhancing technological development, especially in the footwear cluster, the university has made great efforts in the field of R&D and leather manufacturing innovations and cooperated with many companies to set up the Leather Production Technology Research Center of Wenzhou in 2004 (Lai, Chiu, and Leu 2005).

3.6 Policies and Strategy to Improve the Development of a Cluster:

The government can play a significant role in simplifying the development of clusters through its initiatives, policies, and investment programs.

Examples of the strategic policies and initiatives implemented by policymakers include:

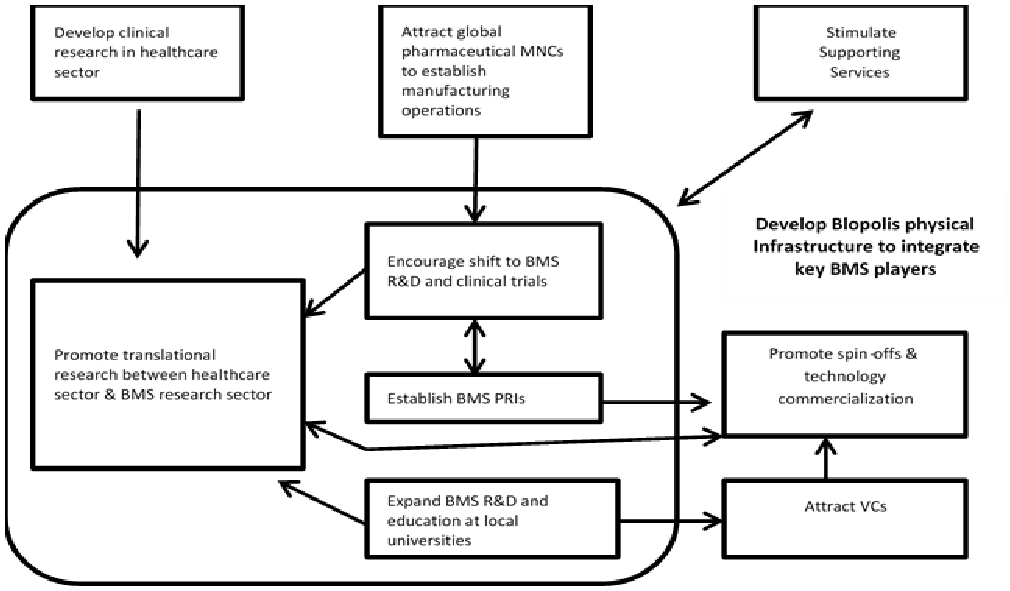
a) The Biomedical sciences (BMS) cluster in Singapore

First, the government has allocated a US$1 billion fund to build new life science research institutes and a complex named Biopolis, in addition, to funding new R&D projects by multinational pharmaceutical companies (Wong 2007).

The Agency for Science, Technology, and Research, and the Economic Development Board (EDB) were the two main governmental entities responsible for establishing Singapore as a biomedical science center. In addition, the Biomedical Research Council was responsible for putting appropriate policies and educational plans that will enhance biomedical science competencies e.g., funding and research initiatives. The EDB core responsibilities are attracting investments to develop long-term economic growth in the BMS sector (Finegold et al 2004).

Figure 2 presents a flowchart demonstrating different strategies developed by T&R and EDB to develop the BMS cluster in Singapore.

Figure (2): Flow-Chart of Singapore's BMS Cluster Development Strategy



Source: Wong et al., 2010

Singapore has attracted global talents in BMS development. The Biomedical Sciences Executive Committee which drives Singapore's BMS Initiative is managed by the International Advisory Council (IAC), which encompasses superior scientists from all over the world.

BMS hub development: key elements of development strategy
a) Attracting FDI into industrial, engineering, and R&D centers; b) Developing varied and connected infrastructure to attract potential investors into the cluster; c) Attracting top (local or foreign/young or senior) talents into the cluster, for example (Sidney Brenner, a Nobel laureate (Chairman of BMRC and Co-chairman of the IAC)); d) The government has played an important role in providing and encouraging different funding initiatives, which were managed by one organization called Bio*One Capital; e) Encouraging linkages among all cluster members, i.e., R&D centers, universities, Biopolis complex, and foreign institutes by a consortium set to promote such linkage. These consortia engage in a variety of activities such as financing, and training (Wong, et al, 2010).

b) The success of Chinese industrial clusters came from governmental support and promotion. This support often takes many policies:

i) local governments have designed, developed, and built well-specialized markets and industrial zones to enhance all activities; ii) local governments are gradually highlighting technological innovation and upgrading. Because of the high cost of investment in innovation and technology upgrading, most firms cannot invest in such activities. So, the government does so. In Guangdong, the government has invested RMB 300,000 in each specialized zone to set up a technology center. In Wenzhou, the government encouraged and invited shoe manufacturers in Italy to set up a footwear design center to help the cluster gain innovation (Zeng, 2012).

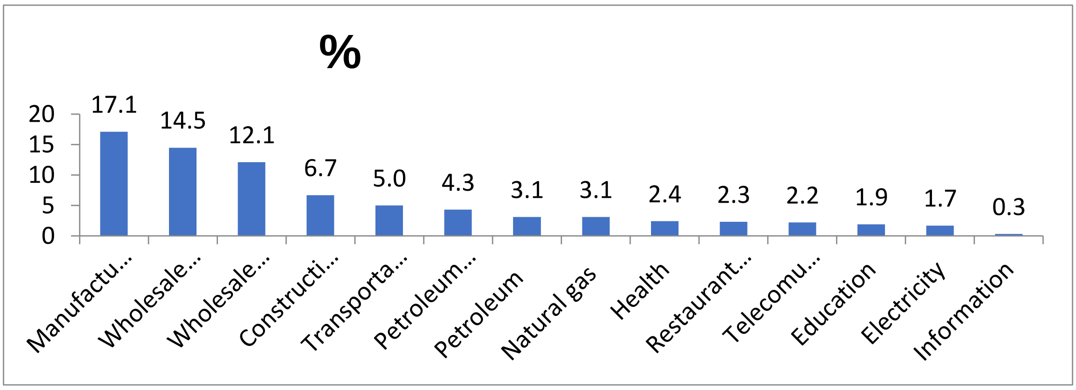
4. Targeted Clusters for the Egyptian Economy

4.1 *The Competitiveness Drivers of the Egyptian Economy*

Deep insight into the Egyptian economy has demonstrated that the most prominent problem of the economy is manufacturing and how to develop this sector (IDSC, June 2022).

The manufacturing share in the Egyptian economy for 2019/2020 was 17%, agriculture 12%, and the service industry 50%.

Figure (3): The relative share of economic sectors in the GDP in Egypt in 2019/2020



Source: (INP, 2020).

The percentage of the added value for the industrial sector has increased very slowly compared to the total GDP for the last 30 years from 27.4%: to 30.8%.

Table (2): **%** Manufacturing value Add of Total GDP of the Egyptian economy in different years.

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2019*	*2020*	*2021*
% Manufacturing value Add of Total GDP	**27.4**	**30.2**	**30.8**	**34.1**	**35.8**	**36.6**	**35.6**	**31.8**	**30.8**

Source: (Mohamed, 2022)

Considering the degree of depth of the Egyptian manufacturing industry and its slow entry into the modern or more advanced industries, such as electronics, machinery, equipment, and vehicles, shows that it is inferior to foreign ones. The data in table No. (3) show the decline in the basic indicators of the depth of the manufacturing industry in the value-added position of medium and high-tech industries, particularly machinery and transport equipment. This means that the depth of the Egyptian manufacturing industry has not witnessed a significant change in the last three decades. This is evident in the small value of Egyptian exports of high-tech products, and the growth in the export capabilities of the manufacturing industry, as the percentage of commodity exports did not bridge the existing gap in the Egyptian trade balance deficit, and the Egyptian economy's import of manufacturing products continued to outweigh its exports.

Table (3): Some Manufacturing indicators of the Egyptian economy in different years**.**

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2019*	*2020*	*2021*
The Added Value in Medium and High Technology Industry as a Percentage of Added Value of the Manufacturing Industry	**23.4**	**25.1**	**36.2**	**29**	**23.8**	**18.5**	**20.9**	**———**	**———**
Total Export of High Technology Industry of Total Manufacturing Export	**———**	**———**	**———**	**———**	**1**	**0.8**	**2.3**	**2.7**	**———**
Total Export of Manufacturing as a % of Total Egypt Export	**———**	**40.3**	**38.4**	**23.6**	**41.7**	**51.6**	**45.2**	**47.8**	**45.6**
Total Import of Manufacturing as a % of Total Egypt Import	**———**	**60.6**	**55.4**	**45.2**	**59.9**	**58.8**	**57.7**	**57.9**	**55.9**

Source: (Mohamed, 2022)

Even though the Egyptian economy has many hidden capabilities that could deepen the activities and turn the economy from assembly to manufacturing, this needs implementing strategies to utilize these capabilities. This turning will be a focal point in the growing economy especially if the expansion in the manufacturing is in the high technology.

4.2 Snapshot of Some Capabilities of the Egyptian Economy:

- In 2014, Egyptian average salaries were about 15 times less than salaries in advanced countries such as Germany, France, and Italy (ILO, 2017). In the ICT sector, the average programmer's salary in Egypt is about 25% lower than that in China and Morocco, 40% lower than the salary of a programmer in Hungary and the Czech Republic, and 70% less than the salary in the UAE (OECD, 2017).
- Egypt was 28th among 141 countries on the index of the quality of roads in 2019 (global competitiveness report, 2019). On market size, Egypt was 23rd in the world and 3rd in Africa and the middle east (global competitiveness report, 2019), with 40% of the Egyptian people between 15:39 accounting for 40 million people, and 21.1% between 40:64 years old accounting for 21.1 million (CAPMAS, Jan. 2020).
- The information and communication technology sector is the fastest growing sector in Egypt, as it achieved a growth rate of about 16.3%, surpassing all the various sectors of the country during the fiscal year 2021/2022. The sector provides 280,000 jobs, and its exports amounted to $4.9 billion in 2021. Egypt already hosts a number of MNCs such as IBM, Amazon, Uber, Microsoft, Valeo and Bright Skies, and others in the IT sector (ITIDA, 2022).
- The state has set up nine business incubators, including distinguished incubators in the field of artificial intelligence at Alexandria university and a technology incubator at Mania University in cooperation with the Academy of Scientific Research and Technology (IDSC, Jan. 2022).
- The productivity rates of the labor force in Egypt are competitive. According to ILO estimates, Egypt witnessed high productivity rates during 2019 that amounted to about 43931 USD/annum compared to low productivity rates in other countries such as Tunisia, Jordan, Morocco, Algeria, South Africa, Nigeria, and India (GAIF, 2019).
- Corporate tax rate in Egypt is less than developing and emerging economies which stands at 22.5% in the country. That is lower than India (25:40%), South Africa (28%), Morocco (31%), and Mexico (30%) (GAIF, 2019).
- Egypt applied 14% VAT in the country which is lower when compared to different countries such as Turkey (15:35%), India (10:30%), South Africa (0:40%), Morocco (0:41.5%), and Mexico (0:30%) (GAIF, 2019).

4.3 What is the most effective strategy the country should follow:

Now we have to ask an important question, should a country follow a strategy of import substitution by substituting domestic products for what it imports? Or should a country follow an export-orientated strategy by improving its capabilities and competitiveness, and entering foreign markets?

In the past, policies of import and substitution were applied in Latin America until the 1980s by building high tariff fees for local industries so that local producers could produce and sell goods that would otherwise be imported. In contrast, Southeast Asian countries like Taiwan, South Korea, and Singapore have preferred an export-oriented strategy. It reduces involvement with capital inflow and allows supply and demand to work in the markets. It emphasizes the government's role as regulator to manage the fairly organized market economy and relies mainly on a private market system to allocate resources, instead of depending on dominance or the commands of a government in directing the production system. After a few decades southeast Asian countries focused on high-return export industries, and had overtaken every Latin American country by the late 1980s. The secret to success was that the government engaged in selective planning and intervention. Rather, the export orientation allowed these countries to gain economies of scale and the benefits of competitive advantages and international specialization, which allows the country to use domestic resources effectively, acquiring fast productivity growth.

4.4 Methods of Collecting Data

This paper has identified the targeted clusters during the period between (2004-2019). This period was selected to avoid any biased data for the period of 2020 : 2021 for the pandemic of covid 19, and to avoid biased data in 2022 for the war between Russia and Ukraine. The current privileged location of Egypt between Asia and Europe and the flow of trade between both continents is considered the most important factor to define the targeted clusters. Therefore, the most important factor is the positive combined annual growth rate for which industries have grown between Asia and Europe or vice versa, more than the world exports growth rate within the period 2004-2019. This variable shows for a specific industry the percentage share of exports of this industry in total world exports. The more an industry exports than the world export rate, the higher its potential is. Hence this index helps to identify which industry has future export potential in the global market. The variables which compose the analysis are:

1- Export-Output combined annual growth rate of the period (2004–2019): measured as the growth of the export of the sector's industrial output from 2004 to 2019 from Asia to Europe. It aims at capturing how the sector has grown during this period. However, the sectors with a higher growth rate than the global export growth rate were chosen.
2- Export-Output combined annual growth rate of the period (2004–2019): measured as the growth of the export of the sector's industrial output from 2004 to 2019 from Europe to Asia. It aims at capturing how the sector has grown during this period, however, the sectors with a higher growth rate than the global export growth rate were chosen.
3- World export-output combined annual growth rate of the period (2004–2019): measured as the growth of the export of the sector's industrial output from 2004 to 2019 from all over the world. It aims at capturing the growth rate of the global supply side of the sectors during this period.

Data for Asia exports to Europe and Europe exports to Asia and the total world exports for all products between 2004 and 2019 were collected from trade map data.

The methodology adopted in this paper was the mixed method approach involving a detailed review of the relevant literature and primary data collected from trade map which was developed in 2001 by the International Trade Centre (ITC), which mainly depends on UN COMTRADE, maintained by the United Nations Statistics Division (UNSD), and integrated with data collected by ITC. UN COMTRADE covers more than 90% of world trade or around 160 countries and regions (http://comtrade.un.org/).

Trade Map is based on the Harmonized System. The Harmonized System (HS) is an international nomenclature for the classification of products published by the World Customs Organization (www.wcoomd.org).

The International Standard Industrial Classification of All Economic Activities (ISIC REV.4) which is used in this analysis, is the international reference classification of productive activities. There is a separate classification that exists, namely, the Central Product Classification (CPC). The relationship between ISIC, on the one hand, and the product classifications HS and CPC, on the other, is based on the fact that the product classifications in principle combine in one category goods or services that are normally produced in only one industry as defined in ISIC.

Hence, we use The Companion Guide of CPC which includes a more detailed interpretation of the link between ISIC and HS.

The classification of industries by technological intensity (technology classification) was made by the United Nation Industrial Development Organization (UNIDO), the taxonomy of industry classified by technological intensity, namely:

- Low technology
- Medium technology
- Medium-high and high technology (MHT industries)

4.4 ***Results***:

Appendices (A, B, and, C) summarize the results for the 93 targeted classes (clusters) for the Egyptian economy. The results were as follows: -

- Low Technology (34 classes).
- Medium Technology (18 classes),
- Medium-high and High Technology (41 classes),

Every class in ISIC has many industries, for example, class number 2750 is called Manufacture of Domestic Appliances. This class includes the manufacture of small electric appliances and electric housewares, e.g., household-type fan.

4.5 Analysis:

Lower-skill manufacturing can be a starting point for cluster development. The literature review has revealed that developing countries should not expect to be able to directly jump into high-tech, but may rather need to go through developing labor-intensive industries initially and then upgrade technologically. Egypt has already built three clusters, two of which are classified as low technology clusters (i.g., Damietta Furniture City, and The Robbiki Leather Cluster), and the third cluster is classified as Medium-high and high technology (i.g., Medicine City "Gypto Pharma" in Khanka).

In the **second** stage, medium industries could be considered. The **third** stage could consider the special emphasis on high-technology industries. Through a number of deliberate government policies, FDI for medium and high-technology clusters could be encouraged by incentives, physical and technological infrastructure, attracting talents, productivity enhancement services (lab facilities, specialized training, consultancies), information services, and strong laws and regulations protecting intellectual property rights (IPR).

5 Conclusion

All advanced economies actively found clusters a worthy method for enhancing economic performance. Policies, strategies, and financing clusters program would provide the initiatives that local and foreign actors at the state and local levels need to build clusters that achieve their goals to compete, provide well-paid jobs, and enhance regional and national economic performance.

A successful cluster strategy is a long-term plan that may not be easy or quick to implement, but the experience proved that it is the best way to achieve economic growth and industrial change.

Appendix **(A): Targeted Low Technology Clusters for Egypt**

ISIC	Description	world exports	Eu exports to Asia	Asia exports to the Eu
1391	Manufacture of knitted and crocheted fabrics	4%	0	7%
1080	Manufacture of prepared animal feeds	9%	14%	25%
1811	Printing	7%	10%	11%
1079	Manufacture of other food products n.e.c.	9%	12%	10%
1430	Manufacture of knitted and crocheted apparel	4%	8%	0
1393	Manufacture of carpets and rugs	3%	0	5%
1410	Manufacture of wearing apparel, except fur apparel	5%	7%	0
1073	Manufacture of cocoa, chocolate and sugar confectionery	7%	10%	0
1103	Manufacture of malt liquors and malt	5%	10%	0
1010	Processing and preserving of meat	6%	9%	0
1040	Manufacture of vegetable and animal oils and fats	7%	20%	8%
1050	Manufacture of dairy products	6%	8%	0
1101	Distilling, rectifying and blending of spirits	6%	7%	19%
1312	Weaving of textiles	1%	0	2%
1030	Processing and preserving of fruit and vegetables	7%	10%	0
1200	Manufacture of tobacco products	5%	10%	9%
1623	Manufacture of wooden containers	5%	10%	0
1061	Manufacture of grain mill products	8%	10%	0
1104	Manufacture of soft drinks; production of mineral waters and other bottled waters	3%	4%	0
3100	Manufacture of furniture	6%	7%	10%
1394	Manufacture of cordage, rope, twine and netting	7%	0	11%

1520	Manufacture of footwear	7%	0	8%
1020	Processing and preserving of fish, crustaceans and molluscs	3%	8%	4%
1399	Manufacture of other textiles n.e.c.	4%	0	11%
1420	Manufacture of articles of fur	4%	7%	7%
2599	Manufacture of other fabricated metal products n.e.c.	7%	9%	9%
2511	Manufacture of structural metal products	8%	0	15%
2593	Manufacture of cutlery, hand tools and general hardware	5%	7%	10%
2512	Manufacture of tanks, reservoirs and containers of metal	5%	0	11%
1702	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	6%	0	13%
1910	Manufacture of coke oven products	2%	10%	0
1701	Manufacture of pulp, paper and paperboard	3%	5%	9%
1709	Manufacture of other articles of paper and paperboard	1%	2%	7%
1920	Manufacture of refined petroleum products	9%	12%	18%

Appendix **(B): Targeted medium Technology Clusters for Egypt**

ISIC	Description	world exports	Eu exports to Asia	Asia exports to the Eu
3212	Manufacture of imitation jewelry and related articles	5%	8%	13%
2393	Manufacture of other porcelain and ceramic products	6%	0%	7%
2392	Manufacture of clay building materials	1%	0%	30%
2395	Manufacture of articles of concrete, cement and plaster	8%	0%	11%
2420	Manufacture of basic precious and other non-ferrous metals	9%	19%	8%
2220	Manufacture of plastics products	7%	8%	8%
2396	Cutting, shaping and finishing of stone	5%	0%	10%
2399	Manufacture of other nonmetallic mineral products n.e.c.	6%	7%	11%
3250	Manufacture of medical and dental instruments and supplies	8%	9%	0%
2391	Manufacture of refractory products	5%	0%	13%
2310	Manufacture of glass and glass products	4%	0%	13%
3211	Manufacture of jewelry and related articles	8%	0%	9%
2211	Manufacture of rubber tires and tubes; retreading and rebuilding of rubber tires	6%	8%	7%
2219	Manufacture of other rubber products	6%	9%	7%
3290	Other manufacturing n.e.c.	6%	0%	10%
2431	Casting of iron and steel	5%	0%	10%
2410	Manufacture of basic iron and steel	4%	0%	0%
3240	Manufacture of games and toys	2%	7%	6%

Appendix **(C): Targeted medium & medium-high Technology Clusters for Egypt**

ISIC	Description	world exports	Eu exports to Asia	Asia exports to the Eu
2023	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	8%	9%	13%
2029	Manufacture of other chemical products n.e.c.	4%	6%	5%
2011	Manufacture of basic chemicals	5%	6%	7%
2720	Manufacture of batteries and accumulators	3%	7%	4%
2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	6%	7%	10%
2652	Manufacture of watches and clocks	6%	9%	-
2651	Manufacture of measuring, testing, navigating and control equipment	6%	9%	10%
2660	Manufacture of irradiation, electromedical and electrotherapeutic equipment	5%	7%	8%
2640	Manufacture of consumer electronics	-1%	5%	-
2814	Manufacture of bearings, gears, gearing and driving elements	7%	9%	10%
2813	Manufacture of other pumps, compressors, taps and valves	6%	7%	10%
2825	Manufacture of machinery for food, beverage and tobacco processing	5%	6%	14%
2822	Manufacture of metal-forming machinery and machine tools	3%	4%	7%
2910	Manufacture of motor vehicles	4%	11%	-
2930	Manufacture of parts and accessories for motor vehicles	5%	9%	9%
2920	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	6%	9%	-
2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	5%	10%	10%

3030	Manufacture of air and spacecraft and related machinery	8%	13%	17%
3020	Manufacture of railway locomotives and rolling stock	4%	10%	14%
3012	Building of pleasure and sporting boats	3%	8%	11%
3091	Manufacture of motorcycles	3%	5%	-
2012	Manufacture of fertilizers and nitrogen compounds	8%	-	10%
2013	Manufacture of plastics and synthetic rubber in primary forms	6%	-	7%
2022	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	5%	-	6%
2030	Manufacture of man-made fibres	0%	-	6%
2670	Manufacture of optical instruments and photographic equipment	4%	-	6%
2610	Manufacture of electronic components and boards	4%	-	6%
2732	Manufacture of other electronic and electric wires and cables	11%	-	25%
2731	Manufacture of fibre optic cables	11%	-	18%
2740	Manufacture of electric lighting equipment	7%	-	11%
2790	Manufacture of other electrical equipment	6%	-	9%
2750	Manufacture of domestic appliances	5%	-	8%
2823	Manufacture of machinery for metallurgy	3%	-	14%
2812	Manufacture of fluid power equipment	11%	-	13%
2824	Manufacture of machinery for mining, quarrying and construction	5%	-	11%
2815	Manufacture of ovens, furnaces and furnace burners	3%	-	11%
2816	Manufacture of lifting and handling equipment	6%	-	10%
2829	Manufacture of other special-purpose machinery	3%	-	8%
2818	Manufacture of power-driven hand tools	5%	-	7%
2826	Manufacture of machinery for textile, apparel and leather production	2%	-	6%
2817	Manufacture of office machinery and equipment (except computers and peripheral equipment)	0%	-	2%

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Requalification of Human Resources Capabilities of Port and Logistics Community

AN OVERVIEW OF THE EXISTING GAP BETWEEN THE UNIVERSITY EDUCATIONAL OFFER FOCUSED ON ENTREPRENEURSHIP AND THE MARITIME CRUISE INDUSTRY. EVIDENCE FROM ROMANIA

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Keywords: university educational offer, maritime cruise industry, entrepreneurship, yacht, cruise ship

ABSTRACT: In this paper, the authors describe the existing situation in the city of Constanta, the largest port city in Romania, from the point of view of the existing discrepancy between the educational offer that encourages entrepreneurship and the maritime tourism industry situation. To reach this goal, the authors first began to analyze the statistical reports regarding the situation of the ships that dock in the port of Constanta. Second, the authors conducted a research on the university educational offer in Constanta. The results showed that out of a total number of 22 faculties, each with at least 2 specializations, only 4 specializations are focused on business management or administration, the others being common specializations that can be found in the rest of the cities in the country. After analyzing the university educational offer and determining the directions for the training of professional skills within the analyzed faculties, the authors presented as a case study the Alezzi Yacht, which offers cruise services only during the summer in the maritime sector on the shores of the Black Sea. In this regard, qualitative research was conducted. Based on the results obtained and the directions suggested by the customer feedback on Alezzi Yacht, the authors highlighted the aspects of the cruise services that must be offered by the personnel working in the cruise tourism industry. Also, the authors highlighted the existing discrepancy between the skills and specializations of the personnel needed in cruise services according to the analysis of customer feedback on Alezzi Yacht, and the specializations offered by the Romanian educational environment to support the development of entrepreneurial initiatives in this directive.

1. INTRODUCTION

The COVID-19 pandemic has curbed one of the most spectacular developments the tourism industry has seen - cruise tourism. If at the end of 2019, a total of 32 million customers worldwide was forecast, the year 2020 brought this industry to the level recorded in the 1990s (Risposte Turismo, 2022). The COVID-19 pandemic, the medical protocols imposed by it and the decision of countries to ban cruises across several countries, brought losses not only at the economic level but also at the social level.

In the cruise industry, crew members play a key role. If before the pandemic, they were employed from over 100 countries, only highly trained and dedicated professionals being chosen (Cruise Lines International Association, 2022), now this industry has to deal with finding crew members at the local level, who will not only do their job for that were initially prepared, but also comply with and implement improved health and safety protocols that protect the well-being of those on board the ships.

Even if previous studies targeting the cruise tourism sector have emphasized directions such as cruising economies (Chang et al., 2016), management and marketing (Bosneagu et al., 2015), cruise vessel operational efficiency (Lau & Yip, 2020), ship safety management, cruising regulations (Sun et al., 2019), the impact of COVID-19 on the cruise industry (Antonellini, 2022, da Silva, 2021) or others, few of them emphasize the need to capitalize on business opportunities, the skills needed for crew members, or the adaptation of the educational offer to the needs of this sector (Ariza-Montes et al., 2021). Thus, a significant research gap is yet to be filled. The goal of this paper is to present the existing gap between the university educational offer focused on entrepreneurship and the maritime cruise industry, offering evidence from Romania. To achieve this goal, the authors illustrate this gap by using a case study that presents the factors that influence the Alezzi Yacht passengers' satisfaction, the case study being a useful method for examining phenomena still unexplored (Di Vaio et al., 2018).

This paper is divided into five sections. The first two sections include the introduction and literature review, with an emphasis on the cruise industry from Constanta and the educational offers from Constanta regarding university studies. In section 3, the authors presented the methodology of this paper, while section 4 presents the results of the qualitative analysis regarding the Alezzi Yacht case study. Finally, the authors provide conclusions in section 5.

2. LITERATURE REVIEW

If in the past, the role of the cruise was related to a mean of transportation, nowadays, a cruise is more related to a "holiday experience" (Lau & Yip, 2020). Cruises refer to "any fare paying voyage for leisure on-board a vessel whose primary purpose is the accommodation of guests and not freight normally to visit a variety of destinations rather than to operate on a set route" (Wild & Dearing, 2000, p. 319–320). On a cruise, passengers spend their time at sea by making different activities such as dining and entertainment but also can go outside the ship when they arrive at the port to make shore excursions and visits (Lau & Yip, 2020). A cruise is more than a form of transportation and a destination (Ahmed et al., 2002), it's a luxury experience (Jones, 2011) that offers comfort and great facilities onboard and at resort destinations (Teye and Leclerc, 1998). Also, a cruise can be seen as a socio-economic system, which is the result of the human, organizational and geographical entities interaction, focusing on creating maritime- transportation-enabled leisure experiences (Papathanassis & Beckmann, 2011).

2.1. The cruise industry from Constanta

Constanta is a Romanian port city located on the Black Sea's western coast (CruiseMapper.com, 2022), being the capital of Constanta county, the 5th in Romania in terms of the number of inhabitants (Barbu et al., 2022). Constanta Port is a maritime and river port, being located on the Western coast of the Black Sea (Barbu et al., 2020). Constanta Port is the Black Sea's largest, and Europe's 18th-largest cargo port (CruiseMapper.com, 2022).

Regarding the cruise industry, Constanta is visited by yachts and smaller-sized luxury ships. In 2020, among the ships that had reservations on the Constanta cruise market, there were ultra-premium cruise travel brands like Azamara, Phoenix Reisen, Fred Olsen, RSSC-Regent Seven Seas, Crystal, Oceania, Silversea, or SeaDream (CruiseMapper.com, 2022). However, due to COVID-19 pandemic, in 2020 there were no passenger's ships registered in Constanta Port Annual Report (Table 1).

Table 1. Calls of sea-going vessels by type of ship/year (2015-2021)

Calls of sea-going vessels by type of ship/year	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Passenger	37	17	13	11	17	0	3
Cargo	1971	1812	1815	1785	1807	1927	1751
Portcontainer	610	684	592	524	510	475	494
Tank	668	665	608	670	687	581	587
Bulk carrier	589	607	574	628	622	558	645
Others	730	546	491	521	533	490	505
Total	4605	4331	4093	4139	14176	4031	3985

Source: Constanta Port Annual Report 2021, 2021, https://www.portofconstantza.com/pn/page/np_statistici_port

Also, even if the pandemic brought dramatic changes in all industries, in the period 2015-2021, the passengers' calls of sea-going vessels began to register massive decreases, starting from 37 in 2015 to 3 in 2021 (Table 1).

Regarding the situation of maritime passenger ships for 2022, in Table 2 it can be observed that there were 40 sea vessels announced for 2022.

Table 2. The situation of maritime passenger ships for 2022

The situation of maritime passenger ships	*Number*
Sea vessels announced for 2022	40
Sea vessels that canceled the visit for 2022	18

Source: Stirileprotv.ro, 2022, https://stirileprotv.ro/stiri/actualitate/prima-nava-de-croaziera-din-acest-an-a-acostat-in-portul-constanta-peste-120-de-turisti-straini-au-ajuns-in-romania.html?utm_source=youtube_stirile_protv&utm_medium=description&utm_campaign=stirileprotv

Unfortunately, the number of cancellations started to increase (at least 18 cancellations), a situation due to the war between Ukraine and Russia, which is seriously affecting cruise tourism in Romania. More than that, the losses generated by this unfortunate and unstable situation also extend to other industries, in the Constanta area being affected not only the event organization sector for maritime ship passengers but also wine tourism (those who dock at the port and led to the wineries of Dobrogea and the traditional shows ended up paying at least 50 euros per person for this experience).

Thus, in order to be able to face such uncertain situations, it is necessary to intervene on several levels (economic, social, and political) so that the cruise tourism industry in the Constanta area can recover and begin to be exploited at maximum capacity.

2.2.The workforce needed in the cruise industry

The papers published in the area of cruise tourism indicate that one of the big problems of this sector is related to the workforce (Ariza-Montes et al., 2021). It is difficult to find skilled and willing people to work in this sector, especially due to the unattractive conditions in this sector: low job security and stability, uncomfortable work schedules and long working hours (Ariza-Montes et al., 2019), uncompetitive wages (Deery & Jago, 2015); work–life conflict (Lin et al., 2014), low social prestige (Murray-Gibbons & Gibbons, 2007).

According to Gibson (2006), there are three important groups of employees in the cruise industry: officers (e.g. captain, chief engineer, hotel director, or cruise director), crew (e.g. motormen, waiters, deckmen or cooks), and staff (e.g. photographers, shop managers, hairdressers, aerobics instructors, entertainers, and tour guides), while officers and crew can be grouped into four departments (deck, engineering, radio, and hotel services). Taking into account the fact that each of these crew members has a well-defined role on the board of the ship, it is important for the ship management to find trained, experienced people, as soon as possible, who are willing to work in this sector. Thus, in the following section, the authors present the existing educational offer at the level of bachelor's and master's studies in the city of Constanta in order to see both the type of specific training of future graduates, as well as the possibility of "raising" entrepreneurs or managers who can capitalize on the opportunities of the cruise tourism sector.

2.3. Educational offer from Constanta regarding university studies

The educational offer from Constanta is quite limited, but large enough for a port city. There are 2 state universities ("Mircea cel Bătrân" Naval Academy and Ovidius University of Constanţa), with a total of 19 faculties. In addition, there are 2 private universities that complete the educational offer: "Andrei Saguna" University and "Spiru Haret" University, the branches in this city having 3 faculties.

The authors analyzed the bachelor's degree programs and the master programs from these 22 faculties in order to determine what are the directions for the training of professional skills within the analyzed faculties from Constanta. All the faculties have at least 2 different specializations for the bachelor's degree programs, and most of them have also more than 2 different master's programs (Table 3).

Of all the 4 universities, "Mircea cel Batran" Naval Academy from Constanta offers bachelor's and master's programs in the maritime, fluvial and port fields, being one of the most thematic universities in the country dedicated to the city where it is located. This university comes with an educational offer that meets the need for professionals of the Romanian Naval Forces, the Border Police and the economic environment in the naval and maritime and fluvial port fields.

Table 3. Educational offer from Constanta regarding university studies

Universities	*Faculties*	*Number of bachelor's degree programs*	*Number of master's programs*
"Mircea cel Bătrân" Naval Academy	Faculty of Marine Engineering	6	2
	Faculty of Navigation and Naval Management	3	3
	Faculty of Electrical Engineering and Naval Electronics	2	1
Ovidius University of Constanţa	Faculty of Arts	5	5
	Faculty of Construction	2	2
	Faculty of Law and Administrative Sciences	4	7
	Faculty of Physical Education and Sport	3	3
	The Faculty of Pharmacy	2	2
	Faculty of Mechanical, Industrial and Maritime Engineering	6	4
	Faculty of History and Political Sciences	3	2
	Faculty of Letters	5	5
	Faculty of Mathematics and Informatics	3	3
	Faculty of Medicine	3	2
	Faculty of Dentistry	2	0
	Faculty of Psychology and Educational Sciences	4	2
	Faculty of Applied Sciences and Engineering	4	4
	Faculty of Natural Sciences and Agricultural Sciences	6	5
	Faculty of Economics	6	12
	Faculty of Theology	4	5
"Andrei Saguna" University	Faculty of Psychology, Behavioral and Legal Sciences	2	2
	Faculty of Economic and Administrative Sciences	2	2
"Spiru Haret" University	Faculty of Legal Sciences and Economic Sciences	3	5

Regarding the types of skills that can be obtained by the students of "Mircea cel Batran" Naval Academy from Constanta, the following directions of training can be mentioned: Marine and Navigation Engineering, Electrical Engineering and Engineering and Management. In this regard, those who are interested in the maritime field can register to attend courses in the civil section (study programs in Naval and Port Engineering and Management, Navigation and Maritime and River Transport, Electromechanics and Naval Electromechanics), at the military department (Navigation, Hydrography and Naval Equipment, Electromechanics, Naval Electromechanics and Naval Architecture study programs), or they can improve their knowledge by taking master's courses in fields such as Naval Electromechanical Systems, Nautical Sciences, Oceanography and hydrography, Logistics Systems Management, Naval and Port Engineering and Management and Operation and Management of Naval Electroenergetic Systems.

The Ovidius University of Constanta is the other university of general interest in Constanta. It has a faculty dedicated to the specific needs existing in a port city (Faculty of Mechanical, Industrial and Maritime Engineering), as well as other 15 faculties that are intended to train future specialists in different fields, but necessary in any city or location. These faculties offer training in the medical field

(Faculty of Medicine, Faculty of Dentistry, Faculty of Pharmacy, Faculty of Psychology and Educational Sciences), the geopolitical field (Faculty of History and Political Sciences, Faculty of Natural Sciences and Agricultural Sciences), science and economic field (Faculty of Applied Sciences and Engineering, Faculty of Economics, Faculty of Mathematics and Informatics), construction and law filed (Faculty of Construction, Faculty of Law and Administrative Sciences), but also other complementary fields (Faculty of Letters, Faculty of Arts, Faculty of Physical Education and Sport, Faculty of Theology).

Apart from these educational programs offered by the two big mentioned universities, in Constanta, there are 2 private universities that come to the support of those who want to obtain a certification in other fields of interest for the economy of the city of Constanta. On one hand, there is "Andrei Saguna" University which comes with an educational offer that focuses on two major directions: Economic and Administrative Sciences, but also Psychology, Behavioral and Legal Sciences. On the other hand, "Spiru Haret" University is an interesting option for those interested in Legal Sciences and Economic Sciences.

Taking into account that Constanta is more than a port city, with multiple economic opportunities, the authors were interested in analyzing the existing specializations in the university educational offer in terms of the training offered in the field of business management or administration. Thus, they identified only 4 specializations focused on business management or administration which can be found in the offers of 4 faculties (Faculty of Mechanical, Industrial and Maritime Engineering, Faculty of Economics from Ovidius University of Constanţa, Faculty of Economic and Administrative Sciences from "Andrei Saguna" University, Faculty of Legal Sciences and Economic Sciences from "Spiru Haret" University). This aspect suggests the fact that 5% of the university educational offer of bachelor's degree programs emphasizes how young people can learn skills, gain knowledge and competencies to be able to take advantage of the opportunities in the Constanta area, to transform those opportunities into business ideas and to manage businesses to both increase profits and bring value to the market. 21.25% of the bachelor's programs and 12.82% of the master's programs focus on learning skills specific to port areas, approximately 16% train engineers, while the rest of the offers are divided between all the other sectors of activity of an economy.

3. METHODOLOGY

In order to meet the proposed objective of this paper, the authors conducted qualitative research to analyze the existing gap between the university educational offer focused on entrepreneurship and the maritime cruise industry. First, the authors consulted the specialty literature and the official annual reports about the cruise industry. In this stage, the authors consulted the Constanta Port Annual Reports to present the situation of the cruise industry from Constanta, by analyzing the situation from 2015-2021. Second, the authors analyzed the official web pages of the four universities from Constanta, Romania. In this stage, the authors analyzed the existing educational offers at the level of bachelor's and master's programs, as well as the specializations that can be followed within each faculty in Constanta. Third, the authors presented as a case study the Alezzi Yacht, which offers cruise services in the maritime sector on the shores of the Black Sea. In this stage, qualitative research was conducted. By analyzing the customers' reviews, the authors determined the main factors that influence the passenger cruise experience. Finally, the authors highlighted the existing discrepancy between the skills of the employees needed in cruise services according to the analysis of passengers' feedback on Alezzi Yacht, and the specializations offered by the Romanian educational environment to support the development of entrepreneurial initiatives in this directive.

4. RESULTS - THE ALEZZI YACHT CASE STUDY

Alezzi Yacht is a cruise ship that offers a sea experience along the Romanian coast along the Black Sea coast and a culinary escape for an unforgettable lunch, the choice of a sunset dinner, an extraordinary club night or participation in various worldly events. In addition, Alezzi Yacht deals with the organization of private events. The service portfolio of this cruise ship includes the organization of weddings, baptisms, anniversaries, and surprise parties, as well as the organization of corporate events (company parties & teambuilding, product launches, exhibitions and conferences, meetings of business, seminars and work sessions) (Alezziyacht.ro, 2022).

The cruise ship has a seating capacity of 780 and has three public decks. The Alezzi Yacht is moored in Berth 9 of Midia Port, the departure point for mini-cruises to Tomis Port. The ship is owned by the Stop SRL company, owned by the businessman Costică Zelcă from Constanta, who invested over 10 million euros in this catamaran yacht, built in the shipyards in Turkey (Zagoneanu & Bușurică, 2021). The ship was specially designed for unique experiences to the rhythm of the music, being not only a cruise ship for transporting people, but also a floating bar/restaurant vessel (Hagi, 2021).

Alezzi Yacht offers not only 4-star services and accommodation but also private transport services, lights, sound and festival effects, customized menus, consulting services, assistance throughout the event, and artistic impresario services. In addition, this cruise ship can be a perfect location for photo shoots, video shoots and other video productions, especially advertising (TV commercials). Access to the ship is made only on the basis of online reservation, following the payment of an access ticket on the ship. All other services offered on board the ship are chargeable, passengers having to arrive at the boarding area at least 60 minutes before the time set for departure, in order to check-in at the specially arranged points (Alezziyacht.ro, 2022).

The experience of the passengers who crossed the threshold of the Alezzi Yacht cruise ship is presented in the reviews section both on Google and on Facebook. On Google, Alezzi Yacht registers a general score of 4.6 out of a maximum of 5, obtained from a total number of 275 reviews. On Facebook, the overall satisfaction score is 4.8, obtained after 260 reviews. The authors of this paper analyzed each of the 535 reviews and, based on qualitative research, determined the main factors that influence the overall satisfaction score of the passengers of the Alezzi Yacht cruise ship.

Thus, the identified factors are: employees, food, drinks, prices, atmosphere, music, the facilities on the ship, time and distance. For each of these factors, the authors analyzed the reviews related to these directions, centralized them and presented them in Table 4.

Table 4. Factors affecting the general score of Alezzi Yacht passengers

Main factors	*Factors*	*Google reviews*	*Facebook review*
Employees	careful	90.91%	85.00%
	empathetic	89.82%	80.00%
	qualified	80.00%	55.77%
	smiling	9.82%	43.46%
	enough employees for the existing capacity	2.91%	1.15%
	dress thematically	4.36%	4.62%
	polite	52.73%	55.77%
Food	tasty	89.09%	33.46%
	served at the right temperature	11.64%	2.69%
	the right amount of food	0.73%	0.38%
	looking good	68.00%	23.08%
	luxury food	11.64%	21.54%
	specialties served	23.64%	13.08%
	great variety	43.64%	40.77%
Drinks	great variety	7.64%	9.23%
	right price	3.64%	8.85%
Prices	suitable for the offered quality	15.64%	13.46%
Atmosphere	relaxing	58.18%	43.46%
	festival atmosphere	83.27%	90.00%
	clubbing	83.64%	85.00%
	exciting	90.18%	91.15%
	unforgettable	93.09%	92.31%
	friendly	29.82%	26.54%
	the place where you can meet new people	28.36%	33.08%
	the place where you can have fun	94.55%	94.23%
	the place where you can dance	72.73%	81.54%
	the place where you can attend concerts	68.00%	43.08%
	the place where you can admire the sea	20.36%	21.54%
	the place where you can enjoy the sunset	12.36%	33.46%
	the place where you can enjoy with your family and children	41.09%	43.85%
	the place where you can enjoy with friends	64.73%	55.77%
Music	great variety	94.55%	97.31%
	live music	74.18%	76.15%
	DJ	56.73%	78.46%
	live band	64.00%	71.92%
	concerts	12.36%	65.38%
	festival atmosphere	83.27%	90.00%
	good sound system	60.00%	72.69%
The facilities on the ship	new	31.64%	25.77%
	luxuriant	16.36%	20.38%
	comfortable	12.36%	21.54%
Time and distance	usually between 3 and 5 hours	52.73%	13.08%
	adapted according to the event	1.09%	2.69%
	around the port	37.45%	55.00%
	by the sea, approximately 1 km from the shore	37.45%	48.08%
	during the day	20.36%	8.85%
	at sunset	31.64%	17.69%
	in the night	48.00%	73.46%

In Table 4, the authors presented the percentage of the reviews where people were satisfied with their experience on the Alezzi Yacht. The factors that stood out the most in the analyzed comments were those related to the music, the atmosphere on the cruise ship, but also the employees on board. Most of the people (more than 90% of them) claimed that Alezzi Yacht is a place where you can have fun, giving you an exciting and unforgettable experience. Also, with a festival and clubbing atmosphere, it is a great place where you can dance (more than 80%). The variety of music is very important for the passengers (more than 94%), especially since the music is live, the atmosphere being entertained by DJs, live bands or famous artists.

Regarding the interactions with the Alezzi Yacht's employees, the passengers appreciated that the cruise staff is very careful with their needs, being empathetic with them and qualified for their jobs (more than 80%). The analysis of the reviews on Google revealed that people appreciate the taste of the food (89%), while the analysis of the reviews on Facebook showed that the night experience is highly appreciated by the passengers (73%).

Following the analysis carried out, the authors also found the factors that still displease the passengers of the cruise ship. Regarding the employees dimension, the passengers considered that sometimes the yacht is overbooked, and there are not enough employees for the existing capacity or the existing number of clients. Also, sometimes employees are dress thematically according to different types of events, but they would appreciate to enjoy this aspect more often. In addition, customers would appreciate even more if the employees were not only polite, but if they smile much more often.

From the analysis of the reviews, the authors observed that few clients mentioned the right amount of food, and the way food is served (right temperature, plating, specialties, variety), as well as the drinking offer (variety and price). Taking into account that the cruise ship is also a floating bar and restaurant, this aspect should be a problem for the Alezzi Yacht. They need to make some changes in order to make clients happier with their food or drinking experience, talking also into account the right price for the entire experience.

Regarding the atmosphere on the cruise ship, the management and the stuff of the ship should pay more attention to details and marketing activity in order to highlight that Alezzi Yacht is a place where you can admire the sea, enjoy the sunset, or spend quality time with your children, family, friends or other people interested in having fun.

Also, it was interesting to notice that only a few clients appreciate the new, luxuriant and comfortable facilities on the ship. This aspect could be explained by the fact that these facilities could represent the basic facilities of a system of service providers in this industry, with clients expecting that they must be present in the services. If they were not present, then they would be dissatisfied, but being basic requirements for them, their presence does not change much the overall satisfaction score.

The last aspect analyzed by the authors was the time and distance of the cruise. A small part of them appreciated that the cruises were available during the day, or the sunset, while the majority appreciated that the cruises were at the night. Also, clients indicate some small problems regarding the time of the cruise (sometimes less than the promised time) and also the distance from the seashore (around the port or approximately 1 km from the shore). Regarding these problems, the yacht management informs the passengers that unforeseen situations may occur (e.g. - bad weather, strong wind, rain, waves of high intensity) in which case the cruise ship staff will take all necessary measures the readjustment of the event from the point of view of redistributing the participants to other covered decks or, as the case may be, in the event that during the outing, for reasons beyond the will of Alezzi Yacht, the ship may have to return to the port area or to the dock earlier than planned. In addition, the management of the cruise ship specifies that the predetermined route approved by the competent Naval Authority cannot be modified. However, if the weather will be unfavorable the

Naval Authority will not issue permission to go out to sea, the boat will remain anchored at the dock, will make the return route on the Midia channel, and the event will take place under the respective conditions (Alezziyacht.ro, 2022).

5. CONCLUSIONS

The cruise tourism industry is very important for the development of a country's tourism sector. For many years, cruises are no longer just a means of transport by sea, they have become a real luxurious experience in which passengers can enjoy all the comfort of a 5-star complex on board the ship. However, to maintain such an experience, it is not enough for cruise ships to look good and have the latest and most comfortable facilities. They must have a crew very well prepared for any situation, and above all a polite, smiling and competent crew for all types of services available on board the maritime vessel.

If it is self-evident that there must be employees in the officers category (e.g. captain, chief engineer, hotel director, or cruise director) very well trained, the results of the case study carried out on Alezzi Yacht indicate that on board of the ship there should be well-trained staff from other fields, who will properly deal with the preparation and serving of meals and drinks, ensuring a very good sound and an interactive light show, creating a party atmosphere, immortalizing photo or video moments, as well as offering other types of services that will pleasantly surprise the passengers.

Analyzing the educational offer in Constanta at the level of specializations offered for bachelor's and master's studies, the authors found that there are enough programs to provide training for the technical part required on the board of a cruise ship. However, when it comes to training offered in the area of entrepreneurship or business administration, there is a more limited offer in this direction. This could indicate a problem for the cruise industry in Constanta because it is not enough to offer certain types of services on board a cruise ship, but you have to do it in such a way as to find the most profitable and sustainable solutions for this business area. This aspect is also supported by Lau & Yip (2020), who claimed that the cruise industry requires creative entrepreneurs and innovative management, in order to face the challenges of this industry regarding energy and GHG emissions, sustainable water consumption, waste and pollution management, host community benefit, ecosystem pollution and loss of biological diversity and effective management of cultural heritage.

Thus, even if the passengers place great emphasis on the services offered by the cruise ship crew and the way they behave on board the ship, it is important that in this industry the employees also have an entrepreneurial mindset, so that they can identify the latent needs of the customers, to see the opportunities that can appear in this industry and to find creative solutions to bring added value to economies and society. Unfortunately, the educational offer in Constanta is still not 100% adapted to this type of mentality, the emphasis being on the good functioning of an economy in a classic way (offering the main training for the usual jobs in any city) and less on the development creative tourism, supporting an entrepreneurial mindset, which could help all the industries in the maritime and port area.

Thus, the results of this paper highlight the existing discrepancy between the skills and specializations of the personnel needed in cruise services and the specializations offered by the Romanian educational environment, offering an overview of the existing gap between the university educational offer focused on entrepreneurship and the maritime cruise industry.

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EXPLORING THE POTENTIALITY OF INFORMATION TECHNOLOGY INTEGRATION WITHIN CUSTOMER RELATIONSHIP MANAGEMENT AND KNOWLEDGE MANAGEMENT IN THE POSTGRADUATE EDUCATIONAL ORGANIZATIONS

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Keywords: Customer Relationship Management, Knowledge Management, Information Technology Integration, Customer Satisfaction, Retention and Loyalty.

1. **ABSTRACT:** Customer Relationship Management (CRM) has emerged in recent years as one of the most challenging issues and an outstanding point in the world. There is a minority of Higher Education Institutions (HEIs) adopting CRM systems as the reviewing literature indicated that there is a lack of wide-ranging researches that discussed the association of CRM with the educational organizations performance. The aim of this paper is to measure the effectiveness of implementing CRM systems and technology on the higher education organizations by assessing how well these systems perform in promoting students' relations and raising customer satisfaction awareness in order to successfully attract, retain and serve them. For that reason, building a sustainable relationship with students is the keystone for acquiring loyal profitable ones. The study relied on the descriptive and analytical approach using both Qualitative and Quantitative methods to describe the subject in a comprehensive and accurate manner through data collection and analysis of the CRM impact on Customer satisfaction. This was accomplished by interviewing key managers from various educational service areas; in addition, survey questionnaires were distributed to a population of postgraduate students in order to obtain a deeper understanding. Since there is a substantial volume of documents and manual work that constitute quite a lot of limitations, this requires data integration into a system which can be accessed at any given time. The findings seem to provide a remarkable contribution to the development of the postgraduate educational services. Meanwhile, CRM remains a discussed phenomenon, the collected data help reaching better familiarity with the topic. Regarding a successful implementation of a CRM strategy, unlimited benefits to the HEIs are supposed to be gained. Such EIs can realize increasing revenue through better market segmentation, customizing and providing high quality services, accessing information in order to achieve scholars' satisfaction, and above all, ensuring long-lasting students'-retention and loyalty.

2. INTRODUCTION

Customer Relationship Management (CRM) evolved to be of considerable use to higher education organizations, for ensuring long-lasting scholars' retention and realizing loyalty. Dowling (2002) affirmed that it is worth mentioning that building a sustainable relationship with customers is the keystone for acquiring loyal profitable ones. As Alomtairi (2009) stated, such organizations can realize unlimited positive impacts by increasing revenue through better market segmentation, customizing and providing high quality services, accessing information to achieve students' satisfaction. Throughout a typical supply chain model, such institutions should view students as customers, and knowledge as the service rendered to them in order to attract, retain and serve students effectively. The educational marketplace is in need to sustain a competitive advantage in the powerful, global developed higher education value proposition.

The aim of this Paper is to assess the effectiveness of CRM systems to be implemented on the educational organizations by measuring the performance of promoting students' relations and raising customer satisfaction awareness. If leveraged properly, valuable insights about the students can be provided to develop strong and personalized relationships with prospective and current learners as well as the graduates. Satisfied students are repeat customers and willing to recommend the brand to their friends and family. Customer loyalty, which is a significant factor in word-of-mouth marketing, increases when providing a solid customer retention strategy. Best Customer Retention Strategies your Business Should Use, (2020).

Customer retention which is considered the next level in the customer satisfaction hierarchy is probably its best measure. Today, Educational organizations must build positive relationships and loyalty to their end customers (i.e. enrolled students, postgraduate students and graduates), because without a considerable number of repeat customers EIs will not long standing. Deif, M. (1998), affirmed that loyal customers become a source for new marketing strategy by means of positive word-of-mouth recommendations. In addition, recent research about service-related businesses strongly indicates that revenue and profitability are higher for processes made by repeat customers than for processes made by first-time or one-time customers (Ibid, 1998).

Managing all the organization's relationships and interactions with actual and prospective customers is the goal to improve relationships for growing the business. Buttle and Stan (2015) affirmed that CRM helps being connected to them, streamline processes, and improve profitability.

3. RESEARCH PROBLEM AND OBJECTIVES

Earlier research found limited impact of CRM themes and aspects on service key performance indicators (KPIs) in the HEIs. Large sector in the postgraduate education deserves more attention within the admission and registration processes to offer distinguished services for the Students. Recently, most of the EIs realized that a system must be applied to services, since students turn out to be the cornerstone for any organization providing educational services.

There are several constraints (gaping flaws) in following up number of the admission and registration procedures for students, as well as a significant amount of paper and manual work; as follow-up operations for students have several limitations. EIs that are not in recourse of a CRM system will be facing rigorous competition from the new educational organizations. Therefore, this paper offers a solution in order to realize some of the main *following research objectives*:

1. Applying a system that can lead to competitiveness among new peers and insuring customer long-term relationships and students loyalty
2. Proposing a smart system by fully digitizing all data and processes.

According to Smith A.D. (2006), any organization needs to implement a CRM system to move beyond the conventional methods of providing services considering it as a competitive advantage. Special features of innovation in service and creativity, moreover building particular characteristic allow any Educational Institution (EI) to be unique in comparison to other competitors, and therefore cause more customers to be attracted and eventually trigger their loyalty.

EIs have to adopt one of the CRM practices in order to build student relationships and ensure excellent services to them before and after graduation through the recruitment of the factors that influence their motivation to the degree completion. Consequently, it will be the strategy to work on to ensure highest customer satisfaction and to gain the return on student experience in terms of goodwill as well as the great revenue.

Data has to be integrated in a system where each department can access at any given time. The information-sharing platform should consist of all the enrolled and graduates students' profiles, with all the relevant details. Students should expect that staff members have then a common understanding about their data, related to contact details, academic performance, qualifications, attendance for lectures, educational progress, all financial details, and so on.

Educational Organizations need to be aware of the students' expectations, and must always have to make necessary arrangements for them to enjoy excellent service all time through managing interaction with current and potential future students. Accordingly, CRM plays a significant mediating role in ensuring the highest levels of satisfaction that contribute to sustaining the long-term relationships with the scholars. So, it is the process of minimizing the gap between the students as customers' expectations and experiences by offering excellent services within the organization's value system with equitable relationships at all stages (Adikaram,C., et al., 2016).

The Educational Organizations will be directly impacted by this study and has the potential to advance communication and set a benchmark for all entities.

4. RESEARCH METHODOLOGY

The methodological approach is qualitative, quantitative, or mixed of both (i.e. triangulation) that is used to conduct research studies (Creswell, (2017); Burns and Bush (2014); Zikmund, (2013); Guba, E.G. and Lincoln, Y.S. (1994)). The study focus is on collecting, analyzing, and interpreting numerical data in a structured way using statistical techniques and a large representative sample of the population.

A deeper understanding of how HEIs can implement CRM is presented to gain sustainable competitive advantages in order to increase its efficiency and effectiveness intending to improve customer services for satisfying students and graduates as well as empowering employees, resulting in a qualitative approach. The research has been completed by constructing a conceptual structure that is carried out prior /subsequent to collection of data.

This is not a prevalent method that can be performed immediately regarding answers. It requires patience, time and tools to piece together a conceptual model as presented later in Figure 2.
The descriptive exploratory design was used to be able to describe the relationship between understanding the concept of CRM and how to be applied. As well as the results would examine its presence according to the research field and scope.

- *Research approach*

In research methodology, both qualitative and quantitative approaches, especially in the field of education, have been taken into account. Abuhamda and her colleagues Ismail and Bsharat (2021) go to that these approaches are regarded as two practical and essential methods in the majority of research studies. Data, whether qualitative or quantitative, cannot indicate or explain something alone; it must be analyzed in order to reveal its significance based on the research questions. Each type of data requires a different method of analysis.
The case study in this research has the purpose as an adaptable qualitative technique of investigation that has a remarkable integrated functionality throughout other qualitative methods. It is one of the research methods in social sciences, that is, the characterization of the situation and incidents, as well as a description of the process of discovery of these elements, which is the research process itself.
Specific information, same questions need to be asked in each interview. A list of specific questions was prepared and an interview schedule has been produced, as well as topics to be discussed. [Ref. Practical Research Methods, (2002)].

- *The case study*

Both qualitative and Quantitative methods were used. The utility and viability of research methods are not defined by following methodological rules; rather, they are determined by the particular environment and phenomena to be investigated, as well as the actual implications of the research strategy (Maxwell. 2012). The case study is presented including survey Questions with students, and interviews with staff management, some enrolled students as well as graduates too. In addition, this study used focus groups with learners in order to have a wide range of responses during one meeting. The qualitative and quantitative data analysis used in this research paper was applied to broaden the scope of developing a better understanding of how the HEI can apply the CRM to add value to postgraduate studies sector through learners and concerned staff management as well as the instructors. The data collected from interviews used content analysis which enabled organizing the qualitative data in order to meet the study objectives and facilitates the reduction and simplification of data while providing outcomes. Data collection is classified into themes and sub-themes so that it can be compared. The qualitative research design is showed in the following research Design Figure 1.

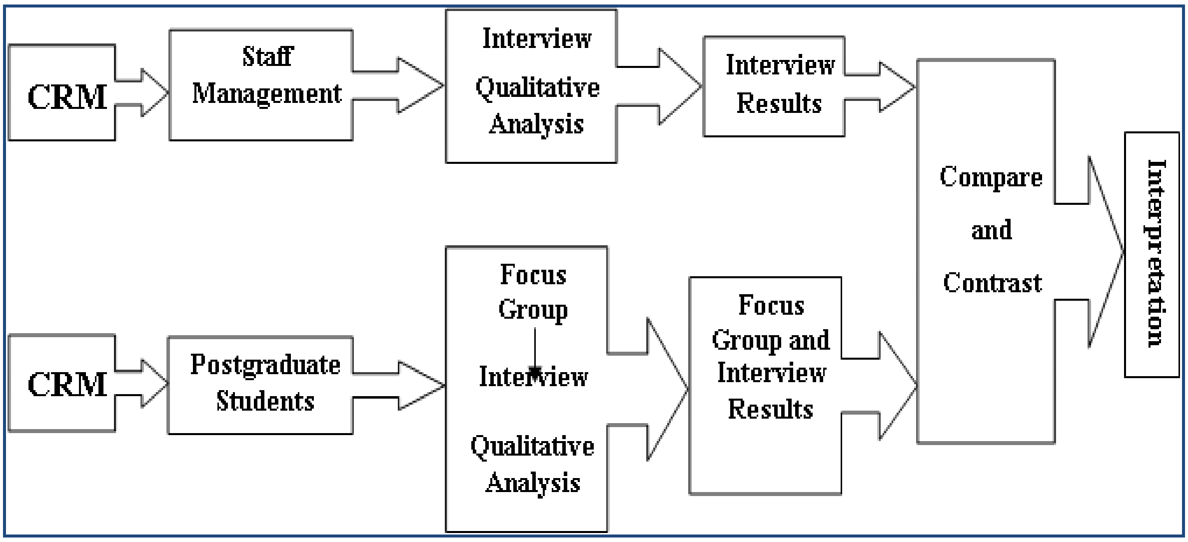

Figure 1 Qualitative Research Design

Once the interview guide and the questionnaire were outlined, a pilot test was carried out to develop the interview questions and the survey questionnaires for participants in order to conform that theoretical and practical terms identified were appropriate to the EIs and to identify the key persons whom responsibilities and duties allow them responding the questions accurately.
The ethical considerations issues concerning the focus groups and interviews have been followed according to the rules. It also represents the discussions of the qualitative and quantitative approaches that have been used in the study: the interview, the focus group and the survey questionnaire.

5. FINDINGS AND DISCUSSION

A CRM system can improve the efficiency of EIs by centralizing, optimizing, and streamlining students' communications. Whereas, it is the technique of analyzing and utilizing databases and communication technologies in order to establish professional guidelines and methods that would enhance the lifetime value potentiality of each individual customer to the organization. (Shaw, E.A., 2018 and Chai, W., 2020).
The key constructs that constitute the findings presented in Table 1 might significantly have contribution to the educational services, and thus preparing distinguished elite of graduates and postgraduates to serve in the country's diverse sectors. (Deif, N. 2022)
The interview started with questions concerning the variety of study programs offered at the Educational Institute postgraduate sector, Learners specializations and their background experiences. These subjects are "*Diversity of Postgraduate Programs and Postgraduate students background experiences*", "*Educational Institution's Reputation and Customer Orientation" and "Customer Trust*". Then, questions about the available "*EI resources"*: The Information provided, "*Advising and Guidance*", and the "*Evaluation levels of Customer Satisfaction*" throughout their studies to the

graduation phase. Questions ended with the Conclusion of "*Word of Mouth*", where the interviewees were asked about their "*Recommendations to new comers for the EI E-Channels*" and what are their "Advices for others".

Table 1 Students Key Constructs

Constructs	Themes
I. <u>Key Constructs</u>: Educational Organizations Reputation and Customer Orientation	**1.**The Diversity of Programs and students Background experiences
	2.Customer Trust
II. <u>Key Constructs</u>: Importance of CRM: Considerations and Assessment for Applying a CRM System, available Resources and Evaluation of Customer Satisfaction	**1.**Available Resources Allocation
	2.Customer Focus: Guidance and Advising
	3.Evaluation Levels of Customer Satisfaction
III. <u>Key Constructs</u>: Word of Mouth	**1.**Recommendations to new comers for E-Channels **2.**Students oriented advices to others for Registration and Enrollment.

Interviewees are classified into *two groups*: graduates and others who are currently in various phases of study, whether they are attending lectures or conducting their researches. The fact is that the majority of them actually be managing working and studying at the same time.

Some questions were asked to discover to what extent the EI's reputation is and to explain how the new comer students were guided through the institution orientation including information about it, several activities and diverse studies fields. As well as evaluating the EI channels whether on websites, the different media, advertisements or word of mouth and their trust.

Most of the respondents agreed upon the sufficient of the provided information concerning the different programs, schedules and fees and how smooth was the online web. A represented percentage agreed upon the clarity of the goals established for EI's development and the main objective for the acquisition and retention of the students, and some of the interviewees declared the need for a student mentor system. The majority are satisfied with the workflow, the organization change and performance, and tuition fees value.

The postgraduate students shared their recommendations regarding the entity with newcomers and also what guidance they could give them.

According to the respondents' feedbacks and Recommendations, it is necessary to apply a CRM system in order to achieve the students' satisfaction through building a sustainable relationship with them. Customer oriented approach, good communications, and system's flexibility lead to attract and retain more students. Now, Customers' relationships are regarded as a key component in the organization in the global market. CRM is one of the considerations of management decisions that leads to have an easier system for admission and registration.

The method of data processing, the understanding of statistical methods and the requirements of each method for certain conditions and hypotheses which are important parts within the research design stages, and that are shown in the Research Model represented in Figure 2 are necessary to give correct results. The SPSS program (Statistical package for social sciences), which is an integrated computer package for data entry and analysis and one of the most important, comprehensive and most common statistical programs was used when dealing with questionnaire forms.

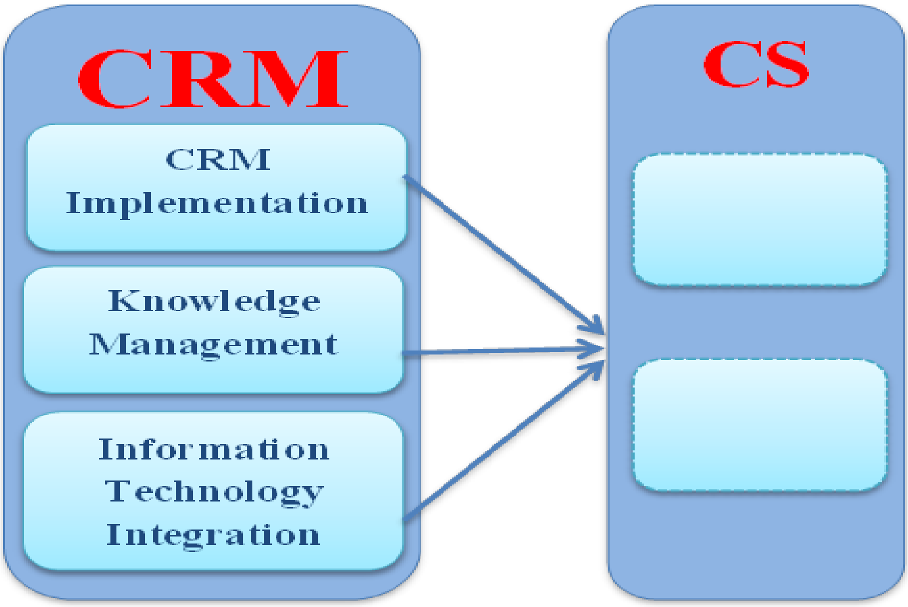

Figure 2 Relationship between CRM and its Variables with Customer Satisfaction

The descriptive statistics presents the different types of Statistical techniques that were used to test the research hypotheses and illustrates the outcomes of the Quantitative analyses. It shows the description of the study variables i.e. (Correlation and Regression).

A. <u>The results of the effect of CRM at customer satisfaction in educational institutions are</u>:

There is a strong direct correlation between customer relationship management and customer satisfaction, where the value of significance = 0.01 is less than ($\alpha = 0.05$).

So the correlation between CRM and the customer satisfaction variables has been proven, which is the study's main Hypothesis.

It can be concluded that customer relationship management influences customer satisfaction. In other words, the better customer relationship management, the higher the level of customer satisfaction is.

Table 2 shows the relationship between customer satisfaction constructs and CRM

Table 2 Relationship between Customer Satisfaction Variables and CRM

		CRM
Customer Satisfaction variables	Correlation coefficient	0.64*
	The value of significance	0.01

*. Correlation is significant at the 0.05 level (2-tailed)

B. The results of CRM practices in educational institutions are:

CRM practices in EIs, in order of their importance, is as follows:

1- **CRM implementation** (with a mean of 4.94) correlation coefficient 0.87** /the value of significance 0.000.

2- **Knowledge management** (with a mean of 4.70) correlation coefficient 0.940** /the value of significance 0.000.

3- **Information Technology Integration** (with a mean 4.84) correlation coefficient 0.890** / the value of significance 0.000.

There is a strong positive correlation between CRM and (CRM implementation, Knowledge management, and Information technology integration) where the value of morale is less than (α=0.05). Table 3 shows the relationship between CRM and its variables:

Table 3 Relationship between CRM and its variables

		CRM
CRM Implementation	Correlation coefficient	0.870**
	The value of significance	0.000
Knowledge Management	Correlation coefficient	0.940**
	The value of significance	0.000
Information Technology Integration	Correlation coefficient	0.890**
	The value of significance	0.000

** Correlation is significant at 0.01 level (2 – tailed)

C-The results of customer satisfaction variables in educational institutions (The detailed variables *presented and discussed in another research paper*) are significant and have a strong direct correlation.

There is a strong direct correlation between the customer satisfaction variables, where the value of significance is less than (α = 0.05).

6. IMPLICATIONS

The marketing situation today makes greater requests to learn about customer preferences, value establishment, products and service customization. Product-centric plans cannot address these advanced requests, but customer-centric plans are developing in response. In exactly this environment if CRM implemented properly, it might represent a challenging competitive means to satisfy new demands. Marketers need a management methodology that realizes increasing customer heterogeneity and addresses concerns about promotional responsibility. Furthermore, that can set available data to suitable usage and includes customer profitability as a significant objective function. This approach is named customer value management. Direct Marketing Association (2010).

7. CONCLUSIONS

Customer Relationship Management has become a component part of business strategy and is not considered only as a marketing tool. The strategy supports management decision making, while using the existing information in the organization and, more importantly, the use of information technology for the marketing programs of the organization.

Today, CRM systems are not just for business, but also help HEIs around the world to provide broad professional experience with distinct challenges and opportunities, from recruiting and marketing to student success and leadership development. In this regard, the need to develop HEIs' strategies for the attraction and retention of students is considered as strategic orientations.

The cumulative availability of technology allows organizations to collect and analyze customer-level data and cooperate with customers consecutively. Rapid changes in the environment in which organizations perform need the growth of new market strategies and a change from a product or service-only focus toward a customer-centric suggestion.

When HEIs implementing the new technologies, they will be experiencing an improvement in reducing the applications processing time and transitioning to a paperless application process to accommodate and become more environmentally friendly for both Management and students in the digital age. CRM systems help HEIs organizing data and guiding students throughout their college lifetime to postgraduate; saving the institution staff time by automating repetitive and operational time, as well as transferring the registration process from complicated spreadsheets to an accessible web cloud.

- *Recommendations*

Through the theoretical study and the field study, and through the information obtained, a number of the following recommendations and proposals can be reached:

First: **CRM Effect at Customer satisfaction in educational institutions**:

HEIs must develop CRM programs to achieve their goals as it provides information relating to customers, such as purchasing behaviors, consuming habits products, services and others. These data and information are used to improve understanding of how to communicate with customers in order to create value and customer satisfaction.

Second: **CRM in educational institutions**:

1-CRM implementation: These are some CRM implementation best practices in today's Education Environment:

1.Map out institutions.
2.Having the best CRM apps.
3.Thinking about integrations.
4.Selecting a CRM implementation team.
5.Set out the organization's metrics, KPIs and goals.
6.Plan a comprehensive budget.
7.Rollout the CRM for an initial stage.
8.Analyze all the collected data and get feedback.

2-Knowledge management: These are some Knowledge management best practices in today's Education Environment:

1.Identify Knowledge Management Goals.
2.Choose Knowledge Management Software that Is Easy to Adopt.
3.Don't Stray from The Knowledge Management Process.
4.Look at Knowledge as an Asset.
5.Consider Employee Needs.
6.Don't Forget the Ultimate End-User: Customers.
7.Monitor Knowledge Management Success with Metrics.

3-Information Technology Integration:

These are some Technology best practices in today's Education Environment:

–Classroom culture: creating a classroom culture supportive of all needed technology.
–Making sure to communicate the learning objectives to the class, when students know what the objectives are, they can focus on the lesson and are more likely to feel motivated to achieve these goals.
–Keep flexibility and patience for emergency purposes.
–Keep students engaged: Adding some variety to the lessons. Implying alternating between few activity types or platforms keeps students engaged.
–Encourage collaboration: To make classes more interactive, have students' team work groups.
–Having support: Chances at the colleagues would help.
–Give feedback: Feedback lets the learner know exactly where they stand with the material, plus it enhances learning and improves a learner's enthusiasm.

- *Future Work*

Despite the interesting findings and implications that emerged from the current study, it is important to recognize its limitation and the need for additional research to enhance the comprehension of the antecedents and consequences of customers' perceptions of CRM after service encounters involving service success.

It is important to investigate customers with different relational orientations since this study revealed that customers behave similarly regardless of the relationship they hold with the organization. Future research can use the framework in the context of service success.

Gathering useful relevant information about the subject including all the necessary details and having easy access to the content with the minimum steps are some of the Characteristics that can help a CRM system effectively. This could come across by finding the right CRM tool for the organization in order to help in analyzing and understanding its requirements as well as working on reducing administration costs and increasing the effectiveness of marketing competition in traditional and electronic markets by optimizing campaigns, product/service configurations, and pricing.

Increasing customer responsiveness and time of customer service, as well as surveillance about the performance of team members and implementation development by improving customer service and enhancing the appearance of the organization, should be done at all stages for building customer loyalty, reducing customer defection, and identifying new opportunities.

Extended CRM models could include software consumption, which hence requires ***Cyber security measures*** and organizations have to continue to invest in ***Artificial Intelligence (AI)*** to automate tasks and augment CRM users as AI and automation would improve CRM outcomes.

Organizations should stay on top of emerging technologies as long as digital transformation is disrupting how business would be conducted. This would help deciding on what technologies to adopt and when to depend on their organizational roadmap and long-term goals.

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STRENGTHENING UNIVERSITY THIRD MISSION THROUGH EDUCATION – ENTERPRISE COOPERATION: THE VALUE OF INNOVATION ECOSYSTEMS

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Keywords: Education-Enterprise Cooperation (EEC), university third mission.

1. ABSTRACT: The aim of this qualitative study is to provide an in-depth insight into the missions and roles of universities in socio-economic ecosystems, with a focus on the third essential direction of education: the relationship with socio-economic partners. Specifically, the paper presents the results of a research that investigated the views of purposefully selected representatives from academia, business, government and public institutions, and civil sector on education-enterprise cooperation in Romania. The research subjects followed an interview protocol, one-to-one, semi-structured interview, where they were asked a series of questions related to their perceptions, opinions and experiences regarding education-enterprise cooperation and the value of innovation ecosystems. 20 in-depth, semi-structured interviews were conducted. In order to strengthen university-business cooperation, the interviewees have suggested: developing strategic action plans to achieve the objectives of working with the university in an effective manner, supporting collaboration between academics and professionals in the socio-economic/business fields to ensure better initial and continuous education of students and graduates and the inception of funding programmes and instruments. Therefore, this research study supports, through the results obtained, the cooperation between education and businesses and provides concrete measures and actions to be taken within innovation ecosystems to boost cooperation and outcomes.

2. INTRODUCTION

European and global societies are moving, at different speeds, towards the transition to a learning society, with a logic profoundly shaped by economic, social, political and, above all, technological change. Developments in the digital sector are intensively and constantly producing change in the world of science and technology. The skill sets, attitudes and competencies that society demands are changing rapidly. In the transactional flow of innovation and social ecosystems, universities have not always been characterised by an alert dynamic and permeability to change, which is why higher education institutions are required to respond to the need for social and individual relevance, to re-create their leadership and governance structures, to redefine their curricular architecture to respond to an alert and unpredictable socio-economic dynamic. The emergence of artificial intelligence in many professions will lead to the construction of significantly different professional development perspectives from those with which universities currently operate. As Aoun (2017) suggests, universities need to create ways of thinking that cannot be easily imitated or replicated by intelligent machines and that will enable graduates to develop careers with societal and economic impact. A robust body of research that has addressed the topic of graduate employability suggests the need to train graduates to become active participants in the learning process and autonomously co-design their lifelong learning (Foer, 2017).

Employability and career success are underpinned by the development of technical competencies, a set of transversal skills and competencies, and competencies related to innovation and entrepreneurship (Zwaan, 2017). Kamp (2019, p. 5) points out that innovation skills will be key resources for graduates of science and technology universities. In this context, universities play a key role in preparing students for a labour market that is increasingly oriented towards the transition to the 5.0 society. The knowledge society is experiencing the evolution towards a learning society in which co-participation in learning, collaborative knowledge management and information dissemination are key drivers of success.

The aim of this research is to provide an in-depth perspective on the missions and roles of universities in socio-economic ecosystems, with a focus on the relationship with socio-economic partners. To achieve this goal, the study was designed to (1) describe the types of cooperation between higher education institutions and various stakeholders in Romania, (2) identify barriers to education-enterprise cooperation (EEC), and (3) propose a comprehensive framework for identifying factors and mechanisms supporting EEC.

Specifically, the paper presents the results of a qualitative research, which investigated the views of different professional categories on optimizing cooperation in innovation ecosystems. The paper relates the third mission of universities to innovation ecosystems and discusses the specificity of the EEC in Romania, analyzing in depth the already existing experiences and responsibilities that have the potential to enhance innovation in higher education institutions and to provide concrete directions for operationalizing the EEC.

3. LITERATURE REVIEW

Higher education institutions - active players in socio-economic ecosystems

There are many reasons why universities can be considered innovation leaders. The mechanisms that interconnect these rationales are associated with the three missions that universities can assume: (1) human capital formation, understood as the primary mission; (2) contribution to the development of knowledge through research activities (second mission); (3) transfer of knowledge and technology to industry and society through technology transfer (tertiary mission). The central mission of producing knowledge in post-industrial societies has given universities an essential role in today's social dynamics. This new centrality becomes intrinsically linked to the role of orchestrating innovation networks linking multiple actors. Governments and companies view universities as responsible actors to fill in missing links, given that these organisations are impartial, have long-term strategies and are less driven by commercial interests (European University Association, 2019, p. 9). In order to fulfil this mission, universities need to be adaptable, strategically oriented, autonomous and intensively engaged with regional and international partners. As a result of the enhanced role of higher education institutions in the socio-economic landscape, we are witnessing a reconsideration of the traditional missions of universities. Etzkowitz & Leydesdorff (2000) argue that higher education institutions, through knowledge production and technology transfer, become the engine of social, cultural and economic development. As a result, a new level of connectivity between universities, government institutions and companies is being discussed. At the level of this triple helix, a fourth category of actors can be introduced: the public, civil society, users and students, society as a whole, seen as partners in the three missions outlined above. A recent paper analysing the role of science and technology universities states that higher education institutions are acquiring a central role in the European innovation-based industry development project, taking on what the authors call mission 3.1. (i.e., open leadership with industry partners) (Bedford, et al., 2018). Successful innovation ecosystems in the future will necessarily be embedded in a globalised, interconnected context animated by collaborative relationships, where information, resources, talent and solutions have a dynamic and efficient route between locations that complement each other or develop competitive relationships, Viitanen (2016) argues. In the context of educational policies promoted at European level, the economic element is intrinsically associated with academia by reaffirming the relevance of the knowledge triangle: education, research and innovation (VDI & ASME, 2015). Europe is good at generating knowledge, but less good at turning it into innovation. Compared to the United States, European regions perform well in terms of the number of scientific publications and citations (metrics of knowledge production), but have a comparative disadvantage in transforming knowledge into innovation, as shown by several indicators, including a low number of patent applications per million inhabitants (measure of innovation) - see Figure 1.

From a public policy perspective, this reality has been addressed by initiating specific measures of a predominantly financial nature. Even though financial support for knowledge-based innovation calls for a multidimensional and complex approach, there is evidence to support that a single ecosystem actor focused approach cannot generate structural change in a short timeframe (Bedford, et al., 2018). A few examples may support the above statement: funding instruments targeted at small and medium-sized enterprises (SMEs), where the high quality of proposals has significantly lowered the success rate (European Commission, 2017); or SME funding to employ PhD graduates, which is generally implemented with very low success rates at national and regional level. In addition, ecosystem approaches have been successful practices with regional, national or international impact.

Education – Enterprise Cooperation: Challenges and Opportunities

The 4th Industrial Revolution (or Industry 4.0) is already having an effect on the labour market. Megatrends such as globalisation, digitalisation and demographic change are having a major impact on the way people work, socialise, obtain information, purchase goods and enjoy leisure time. In turn, these trends are increasingly influencing the skills people need to navigate this complexity, to cope with uncertainty and adapt to this rapidly changing landscape. The challenges are real and should not be underestimated, but there are many actions that can influence adaptation to the dynamics of the world.

Although knowledge is essential because it leads to innovation, it is not enough for a successful career. Success in future careers depends on a combination of technical skills acquired in educational programs, but to an even greater extent on a set of cognitive skills (planning and organizational skills, critical thinking and problem solving), mindsets, thought patterns and beliefs about the world (Aoun, 2017). The most important skills in engineering are: critical thinking, holistic thinking, systems thinking, entrepreneurial thinking, global mindset, cultural agility and continuous learning capacity. All these skills cannot be imitated by (networks of) intelligent machines and are unique to humans. To these can be added other skills that can be developed within the university curriculum and that can be equally important: the ability to design, the data-driven approach, the ability to build coalitions, the ability to lead, and the ability to identify strengths and see things through to completion (Kamp, 2019). Also known as soft skills, they are commonly defined as non-technical skills that enable effective and harmonious interaction with others, are vital to organisations and can affect culture, mindsets, leadership, attitudes and behaviours. These competencies fall into the following categories: (1) advanced communication and negotiation skills; (2) interpersonal and empathy skills; (3) leadership and management skills; (4) entrepreneurship and initiative-taking; (5) adaptability and continuous learning skills; (6) teaching and training skills. They play an increasingly critical role in Science, Technology, Engineering and Mathematics (STEMpathy). In 2015, the World Education Forum organised by UNESCO, together with UNICEF, the World Bank, UNFPA, UNDP, UN Women and UNHCR, adopted the Incheon Declaration for Education 2030, setting out a new vision for education.

The 2030 Agenda for Sustainable Development is a universal and collective commitment, built as "an action plan for people, planet and prosperity" and structured around the 5Ps of sustainable development: people - the social dimension (people), planet - the environmental dimension (planet), prosperity - the economic dimension (prosperity), peace - the ethical dimension (peace) and partnership - the collective and collaborative dimension (partnership). Universities occupy a unique position in society, with a broad mission to create and disseminate knowledge, and are powerful drivers of global, national and local innovation, economic development and social welfare. As a result, universities have a key role to play in achieving the SDGs and will also benefit greatly from them.

Universities fulfil several roles in educating and training students to create a sustainable society: 1. didactic role: education contributes to the evolution of the whole human society and enables adaptation to technical transformations; 2. collaborative role: the strength of universities is the capacity for interdisciplinary research and teaching, and the challenge is to strengthen the links between research and education and between disciplines; 3. Scientific evidence-based knowledge role: universities have a key role in transmitting scientifically proven knowledge and insights; 4. Measurement and evaluation role: universities can measure the effects of different SDG-related actions; 5. Advocacy role: higher education institutions need to continuously advocate the importance of implementing the global goals. In the context of growing demand for innovation, universities find themselves in a new and challenging central position. The role of primary knowledge producer comes with demands and expectations that imply new ways of developing institutional identity. This centrality depends on responsiveness, adaptability and connectivity with both academic partners and external global and local stakeholders (EUA, 2019). Thus, entrepreneurship and innovation are important factors that create the highest added value for local and regional development, and the university that interacts, co-creates and achieves a far-reaching impact on regional, national and global development has been called a "fourth generation university". This university model involves creating its own environment both socially and economically, and in addition to its traditional educational role of providing suitably qualified human capital through teaching (the first mission), its second mission is to conduct scientific and academic research (and to base its educational process on such research) and its third and expanding mission is to create value through the transfer of knowledge and technology from academia to industry and society (Pawłowski, 2009). In this dynamic, cooperation between universities and socio-economic partners is essential. Thus, the present study aimed to investigate the state of the art of EEC in Romania.

4. RESEARCH METHODOLOGY

Participants

In order to achieve the objectives outlined in *Introduction*, 20 professionals *(Non multa, sed multum)* were interviewed, purposefully selected based on their affiliation to the following categories of organizations: academia (12 participants), business (3 participants), government and public institutions (2 participants), civil sector (NGOs, 3 participants). In terms of gender, the selected group was unbalanced (only 6 female participants). All respondents were senior professionals in their respective field, with over 10 years of work experience. 8 out of 20 participants occupy an executive position in their organizations.

Figure 1 synthetizes the socio-demographic profile of the participants affiliated to higher education institutions. Most of the participants have a solid international working experience and reported they have participated in international mobility stages, research projects and have had visiting professor or postdoctoral scholarships. One of the respondents is also affiliated with a university in the United Kingdom. Their experience in leadership positions have allowed them to carry out activities together with business stakeholders or other types of external partners.

Similarly, Figure 2 analyses the socio-demographic profile of the business representatives. Their work experiences are relevant in terms of university-business cooperation. Therefore, they have engaged in a wide range of activities with universities: talent recruitment and inception programmes for students and graduates; research and development projects jointly developed with universities, organizing academic events (e.g. conferences). The participants in this category reported themselves and their organizations as active initiators of business-university cooperation.

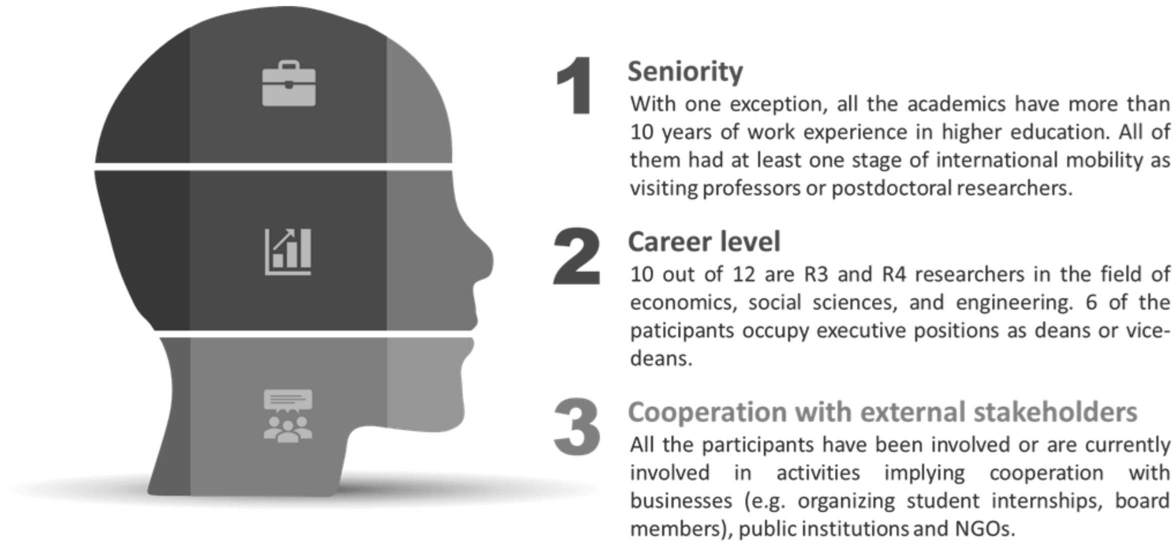

Figure 1: Academics' socio-demographic profile

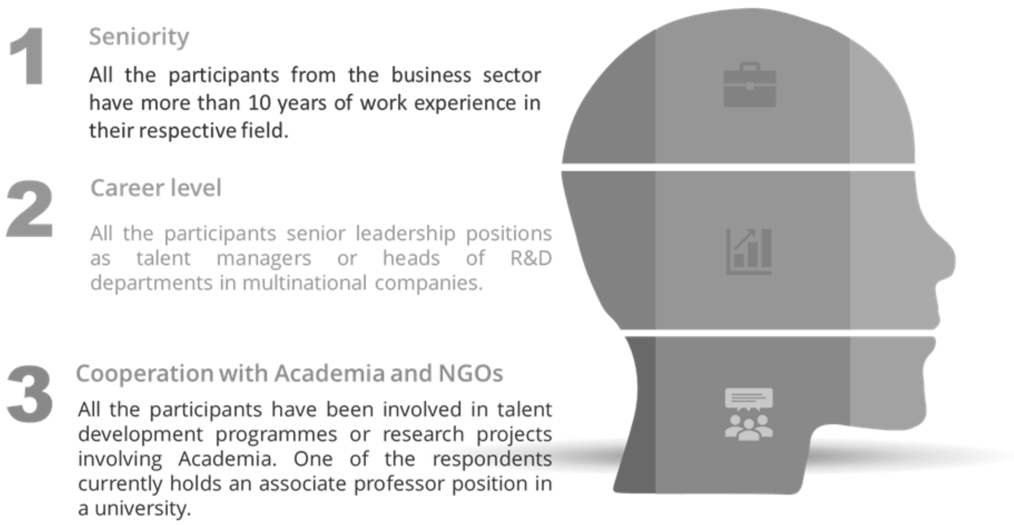

Figure 2: Business representatives' socio-demographic profile

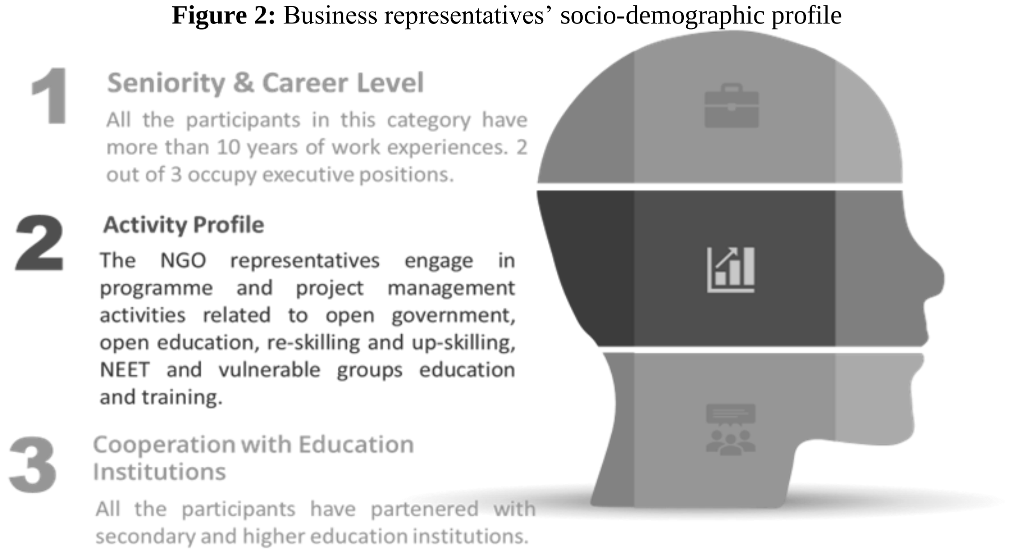

Figure 3: NGO participants' profile

Figures 3 and 4 are summarised in this Organizations' profile:

Type of organization	Description
University	4 universities, located in Bucharest and Cluj-Napoca: 2 technical universities; 1 economic university; 1 comprehensive university.
Private companies	3 multinational companies
NGOs	1 professional organization in the field of coaching; 1 NGO in the field of open education; 1 NGO in the field of NEET and vulnerable groups education.
Government and Public Institutions	2 ministries

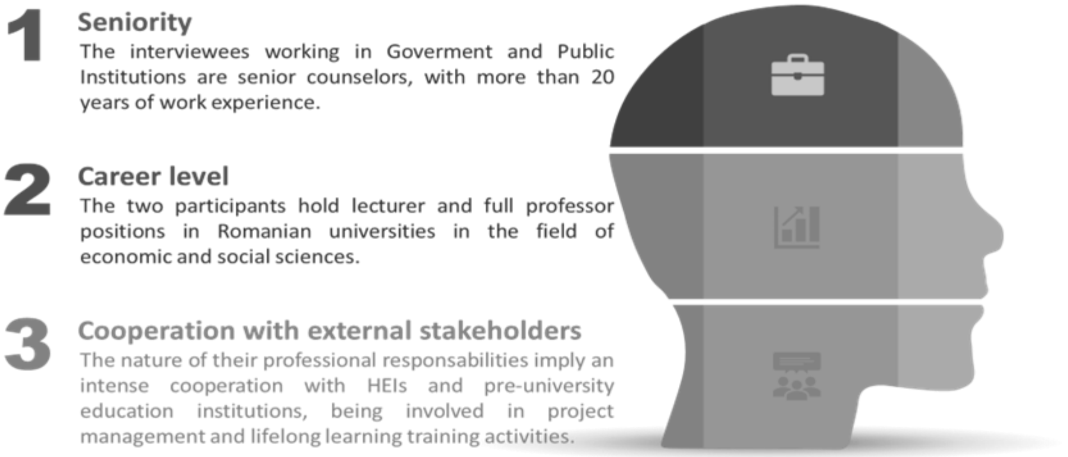

Figure 4: Government and Public Institutions Participants' Profile

Materials

20 computer-assisted, semi-structured individual interviews have been carried out between February and April 2021. The interview was based on an interview guide. The first point in the interview guide has an introductory role, facilitating the discussion. Also at the introductory stage, data were obtained on the respondent's position in the organisation to which he/she belongs, the field in which he/she works and whether he/she has work experience in other fields. The second section focused on investigating views on the EEC, followed by testing the EEC profile and collecting recommendations on the implementation of the profile at national and regional level.

Procedure

Individual interviews were organised online, using the computer-assisted web interview (CAWI) method on the Zoom platform. Before the conversation began, the researcher administering the interview introduced the interviewee to the purpose and objectives of the research and the institution under whose auspices the research is being conducted. The researchers who administered the interviews agreed in advance with the respondents when the interview would take place. Interviews were recorded, identifiers were removed from the transcript, each respondent was assigned an identification number, and responses were centralized to facilitate analysis. Prior to the start of the interview, each respondent completed an informed consent form to formally consent to participate in the research and to use the responses for research purposes.

5. RESULTS AND DISCUSSION

The extent to which EEC takes place is influenced by specific factors related to individuals, organizations, and the supporting mechanisms available at the national level. At the individual level, the interviewees reported themselves to be active initiators of EEC activities. The lack or limited availability of organizational support and funding mechanisms limit the EEC. The absence of comprehensive policies makes individuals and organizations to focus on separate parts of the EEC process. Some of the interviewees argued for a vertically integrated approach to EEC, where three levels are defined: individuals – organizations – regions. As the interviewed representatives pointed out, EEC takes place at all three levels, but the lack of synergies is a major drawback. Moreover, the goals of the three different parties are not fully aligned. The academics argued that the universities tend to stick to long-term policies and development strategies. At the same time, the industry partners are guided by short-term strategies. In other words, there is a disjunction between stability and predictability (in universities) and flexibility and impact (in businesses).

In the following, types of EEC activities, and perceived barriers and drivers of university-business cooperation are discussed. Based on the participants' experiences, a number of three cooperation areas have been identified in education, research and valorization of research results, and management. Given the exploratory nature of the study, these activities are inexhaustive. As all the participants argued, there is room for deepening and extending EEC in all those fields.

Table 1. Types of EEC Cooperation in Romania

EEC areas	Examples of EEC activities
1. EEC activities in education	1.1 (Paid) Internships and placements in companies and public institutions. 1.2. Curriculum co-design (e.g. designing study programmes based on specific technologies provided by industry players). 1.3. Lifelong learning programmes developed by HEIs for external stakeholders / professionals. 1.4. Co-teaching (e.g. co-lecturing, workshops organized in partnership with businesses and NGOs; joint training and open courses); 1.5. Students tutoring 1.6. Cotutelle dissertations 1.7. Recruitment activities (e.g. career fairs organized and hosted by universities, company presentations) 1.8. Scholarships for students 1.9. Student competitions
2. EEC activities in research and valorization	2.1. Joint research projects 2.2. Research laboratories supported by industry partners in universities. 2.3. Incubation labs 2.4. Providing access to research infrastructures to companies 2.4 Patents
3. EEC activities in management	3.1 Joint participation in clusters and boards

Figure 5 synthetizes the perceived barriers to university-business cooperation. Based on the participants' opinions, five categories of barriers have arisen: (1) misaligned goals; (2) insufficient financial resources; (3) skills mismatch; (4) difficulties in partnership building, and, finally, (5) the lack of legislation. Various mechanisms and drivers have been pointed out as beneficial for EEC. The collaboration between the university and companies can be stimulated by the functioning of innovation ecosystems or regional networks/clusters/platforms integrating private companies, universities, research institutes, and NGOs. The functioning of university consortia (e.g., The Romanian Alliance of Technical

Universities - ARUT) was provided as an example for stimulating the research activity and cooperation, though having a reduced role in effective collaboration with businesses.

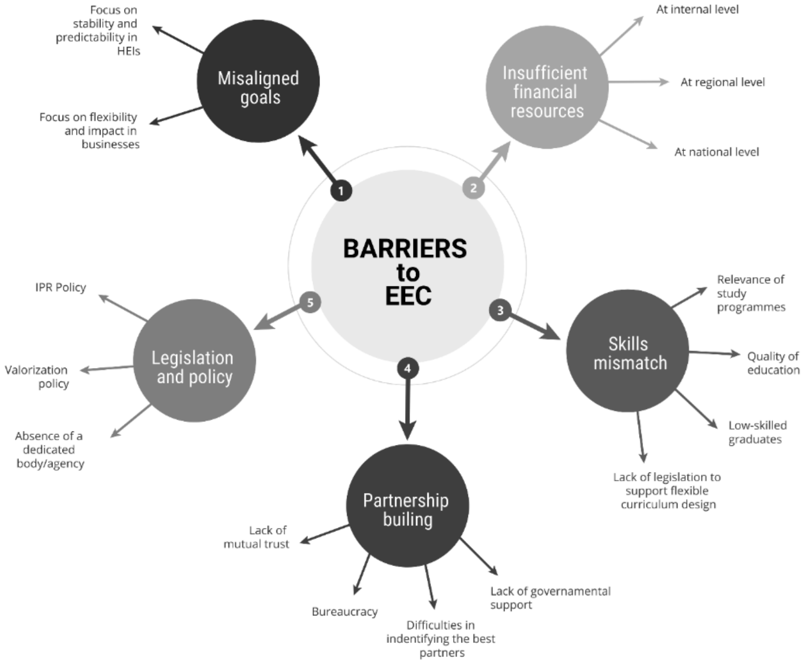

Figure 5: Barriers to Education-Enterprise Cooperation

An alternative to national consortia is international consortia and professional associations to which universities are institutionally affiliated. Participation in such networks provides access to examples of good practice and transfer of knowledge and expertise, ultimately contributing to innovation. The creation *European Universities* as a result of the European Commission's initiative is a relevant example from the perspective of innovation, cooperation policies and curriculum design.

In order to strengthen university-business cooperation, the interviewees have suggested (as shown in Figure 6):

- Developing strategic action plans to achieve the objectives of working with the university in an effective manner (valorization, legislation and policy).
- Supporting collaboration between academics and professionals in the socio-economic/business fields to ensure better initial and continuous education of students and graduates (implementation of consortia).
- The inception of funding programmes and instruments (institutional support).
- Participating in implementation innovation ecosystems.

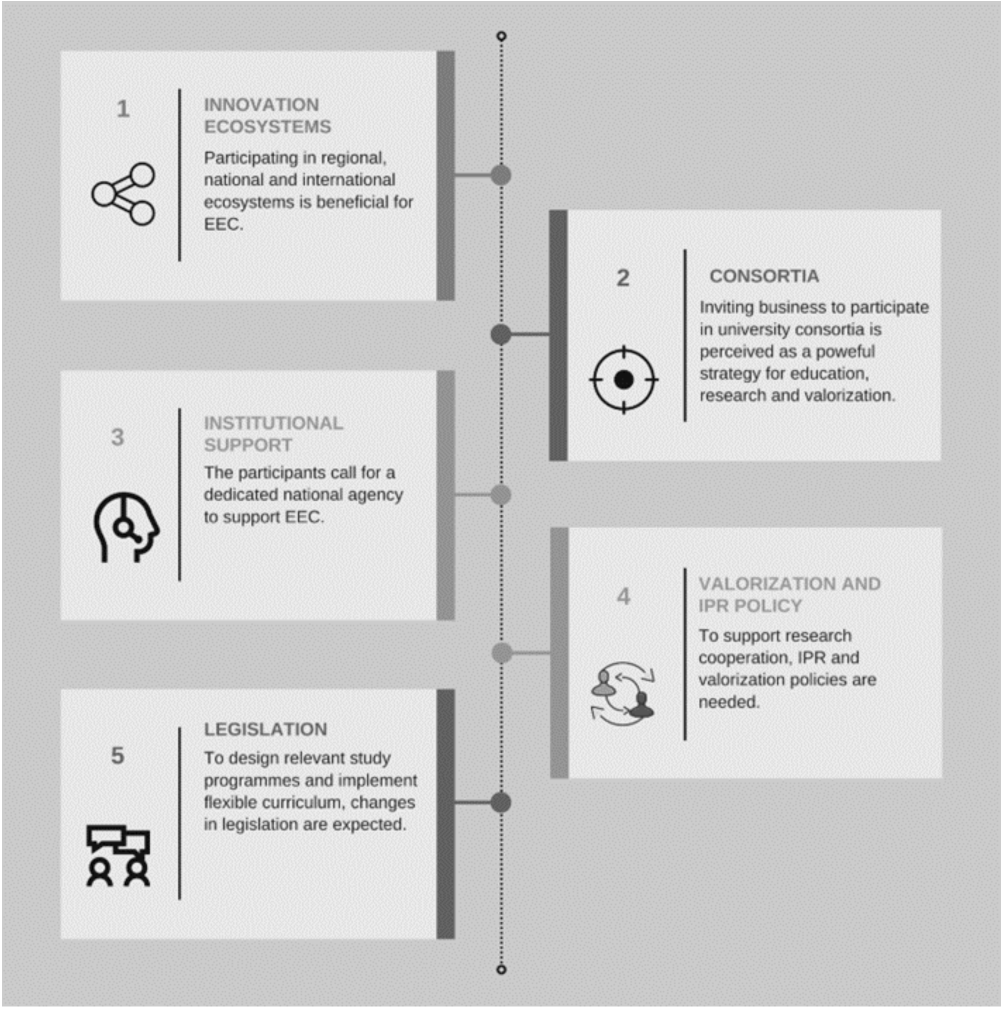

Figure 6: Drivers and mechanisms to support EEC

6. CONCLUSIONS

This study aimed at identifying and evaluating new mechanisms of strengthening EEC.

In order to make study these mechanisms, a qualitative study has been carried out to gain insights about the state of the art of EEC within Romanian innovation ecosystems.

The results showed that, given the right circumstances, EEC in Romania could positively work and have an impact on both processes (e.g., teaching and learning) and outcomes (e.g., learning outcomes). Particularly, both HEIs and businesses are starting to realize that a multidimensional cooperation could be beneficial for all parties involved. Primarily, HEIs are perceived as talent development institutions and businesses expect curricular flexibility, innovation and learning outcomes that will allow the graduates to rapidly immerse in a new job. As expected, HEIs are not seen as innovation and entrepreneurship providers. Romanian academics are involved in a variety of cooperation activities with both private and public sector, but, in most of the cases, those are individually initiated. Thus, the respondents from Academia perceive themselves as active initiators. In this context, they identify the need for a systemic approach to business-university cooperation, financially and institutionally supported.

Some of the private sector representatives stated that they are open to partner with HEIs for local and regional development purposes. Although all the participants identified positive examples of EEC, there is not a clear commitment to building long-term strategic partnerships. The limited engagement impacts the relevance of study programmes and skills on the labor market and, eventually, graduates' employability.

The directions for engaging in partnerships with universities merit further investigation, suggesting possible short- and medium-term measures to make it work in line with the real needs and opportunities uncovered in the stakeholder consultation work.

Building on the development of the 2020 strategic collaboration with UNICEF in support of Generation Unlimited (GenU), which aims to help upskill millions of young people around the world, there is a focus on convening public, private and civil society stakeholders to develop programmes and innovations to support young people on their path to a productive future and engaged citizenship, as well as to conduct research on the global skills challenge. The jobs of the future are likely to require new skills that are harder to obtain in communities where opportunities are lacking. To help bridge this gap, this collaboration supports Generation Unlimited, a multi-sector partnership that aims to help 1.8 billion young people make the transition from school to work by 2030 - in other words, make the transition to Industry 4.0.

The 4th Industrial Revolution, or Industry 4.0 is taking effect in the labour market. This will further evolve into a "5.0 Society", where knowledge will not only be created by humans, but increasingly by algorithms in smart machines from an abundance of sensor data, thus the knowledge society is in a state of transition towards a global learning society (Aldert, Kamp, 2019).

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Optimization of Port Infrastructure and Operation

AN ANALYTIC HIERARCHY PROCESS-BASED SURVEY TO INVESTIGATE THE IMPACT OF TERMINALS' SERVICE ATTRIBUTES ON ATTRACTING SHIPPING LINES

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Keywords:

Ports/Terminals Integration, Analytic Hierarchy Process (AHP), Sustainable Seaports Development, Port Resilience Strategies.

1. ABSTRACT:

Freight movement overseas through ports/terminals around the world plays a huge role in the global supply chain. Improving ports/terminals performance has a positive impact on the overall gross domestic product as well as neighbouring regions. Accordingly, port authorities and terminal operators are keen to improve the quality of the services they offer to increase the number of services calling ports (strings) and the cargo volumes at their terminals.

As such, it is important to understand the behaviour of shippers and the preferences of liners, which opens the way to ask the question, what are the important factors that attract liners to a specific port/terminal?

To contribute to this question, this study aims to understand the determinants of liners' terminal choice behaviour using an Analytic Hierarchy Process (AHP)-based survey.

AHP is a structured technique for organizing and analyzing complex decisions based on mathematics and psychology. It is considered a prescriptive data analysis method that divides unstructured choices into several groups and organizes them into hierarchies.

Expert's and previous researches mentioned that low port dues, access of port facilities and port infrastructure are the most important factors control the choice of a port, on the other hand the outcomes of this research proved that, shipping lines and shippers were concerned more with "Port Efficiency" factor which indicates that liners and shippers recently concerned with the level of congestion and the ship turnaround time, next factor is "Connectivity" which give a higher priorities to the ports that has better connectivity to dry ports, storage, and distribution centers.

In addition, understanding the behaviour of different stakeholders plays a major role towards port resilience strategies to adapt to changing conditions and recover positively from unexpected circumstances like the Covid-19 pandemic, which will shorten the road to attaining sustainable ports and highlight required improvements.

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2. INTRODUCTION

Shipping plays an important role in the world economy. Decision-makers worldwide tend to believe that extending the depth of the draft and increasing the length of the berth through mega infrastructure projects is the optimum way to attract more ships to their ports. However, a different point of view may attribute economies oppression to the development of transport infrastructure that can lead to regional imbalances when such infrastructure investments do not pay back efficiently the costs that are spent on them. As a result, such projects would have negative impacts on the economy [2].

An AHP-based survey was designed and used to gather information on container terminals' service attributes (e.g. adequacy of port facilities, port dues, and turnaround time) and stakeholders' (e.g. shipping lines, cargo owners, and terminal operators) terminal choice behaviour by means of online questionnaires and in-person interviews. In addition, the survey was conducted among representatives of ports and terminal operators, specifically the national container companies operating under the supervision of the Holding Company for Maritime and Land Transport (HCMLT) affiliated with the Egyptian government. Respondents' opinions were then organized into a hierarchic system using a pairwise comparison matrix between the attributes.

The main goal which motivates this research is to ensure that future port development projects would reach the required benefits and giving investors trust to participate in the development of future projects. This will be attained through the following objectives:

- Draw guidelines for port authorities and terminal operators regarding which port/terminal characteristics are more important from stakeholders' point of view when selecting a port/terminal of call.
- Guide decision-makers to market requirements and system weaknesses.

In the following sections, this paper will report on: First, the strategies used to elicit the factors considered in the survey. Second, the steps of building the hierarchical system and designing the questionnaire. Third, calculating a mathematical weight to each factor based on the collected data and analyzing the collected data separately for each group of respondents.

3. RESEARCH METHODOLOGY

Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions based on mathematics and psychology. It is considered a prescriptive data analysis method that divides different choices into groups and manages them into hierarchies [5]. The AHP method is used to convert experts, researchers, and scholars' personal opinions into objective measures [1]. Furthermore, the AHP approach was developed based on the idea that "the best way to conduct a judgment for a group of variables, to decide which variable has a higher priority than the others, is to create a comparison between each pair of elements in different hierarchies" [6]. Furthermore, the AHP method can be applied to demonstrate two types of measurements: relative and absolute. The paired comparison method is used for both measurements to derive priorities based on criteria that serve the main goal. During this study, the AHP method was used to figure out a relative judgment to find the important factors that attract liners to a specific port/terminal. In relative measurement, paired comparisons apply over all alternatives, which guarantees that the lowest alternative in the hierarchy system compares with other alternatives from different levels with respect to the criteria. To start applying the AHP method; first, create a pairwise comparison matrix, then calculate the eigenvector for the matrix and decide a priority vector to the eigenvector to present variables priorities. To evaluate the consistency of the matrix, the eigenvalue is then calculated to decide whether the response will be accepted or rejected.

To apply the AHP method, six steps were followed to reach the required results from applying this method: the first step decide a list of factors and sub-factors from literature reviews and expert opinion sessions, secondly draw the hierarchical structure by deciding the main factors and sub-factors, thirdly establish the pairwise comparison, fourthly find the eigenvalue and the eigenvector, the fifth step is to calculate the consistency ratio for both matrices. Finally, find the weights for each variable and decide which variables have higher priority [9]. These steps are explained in detail in the following sections.

3.1. Establishing a list of factors

Related to the research question, which is, what are the important factors that attract liners to a specific port/terminal?

Expert's opinion sessions were conducted through multiple meetings with different port users to decide which factors attract liners and shippers to a specific port and a specific port terminal. Each expert was asked to list the important factors from their point of view. Researchers and scholars from the logistics field and maritime transport field contributed to these sessions.

After collecting the opinions, a large literature review was conducted through various research papers and studies to compare and decide the final list of the factors and sub-factors that will be listed in the hierarch structure and in the pairwise matrices. The selected factors/sub-factors took into consideration the World Port Sustainability Program (WPSP) which attains the United Nations sustainable development goals through six themes; namely Digitalization, Infrastructure, Health Safety and Security, Environmental Care, Community Building, and Climate and Energy. Each theme has a representative factor in this study to measure the acceptance of the Egyptian market to these factors and to direct decision-makers to which theme they must give a priority to start a sustainability project and invest in this topic.

The list of factors reached nine main factors and 36 sub-factors, which have undergone another round of elimination to reach the final list of 6 main factors and 19 sub-factors, represented in figure 1.

3.1.1. Pilot survey experiment

Before launching the final version of the survey a pilot survey were applied over a group of researchers and experts, the survey were distributed over more than 10 respondents to test the functionality of the designed instrument, respondent were asked after finishing the survey to write any missing factors from their point of view, also state any difficulties they faced while answering the survey, the outcomes of this pilot test were helpful to collect opinions and recommendations to update the survey, there were few adjustments on some sub-factors, also for the online version some adjustments were edited to avoid any misconceptions, infographics and detailed specifications for each factor were added to help the respondent to have more accurate and clear decision.

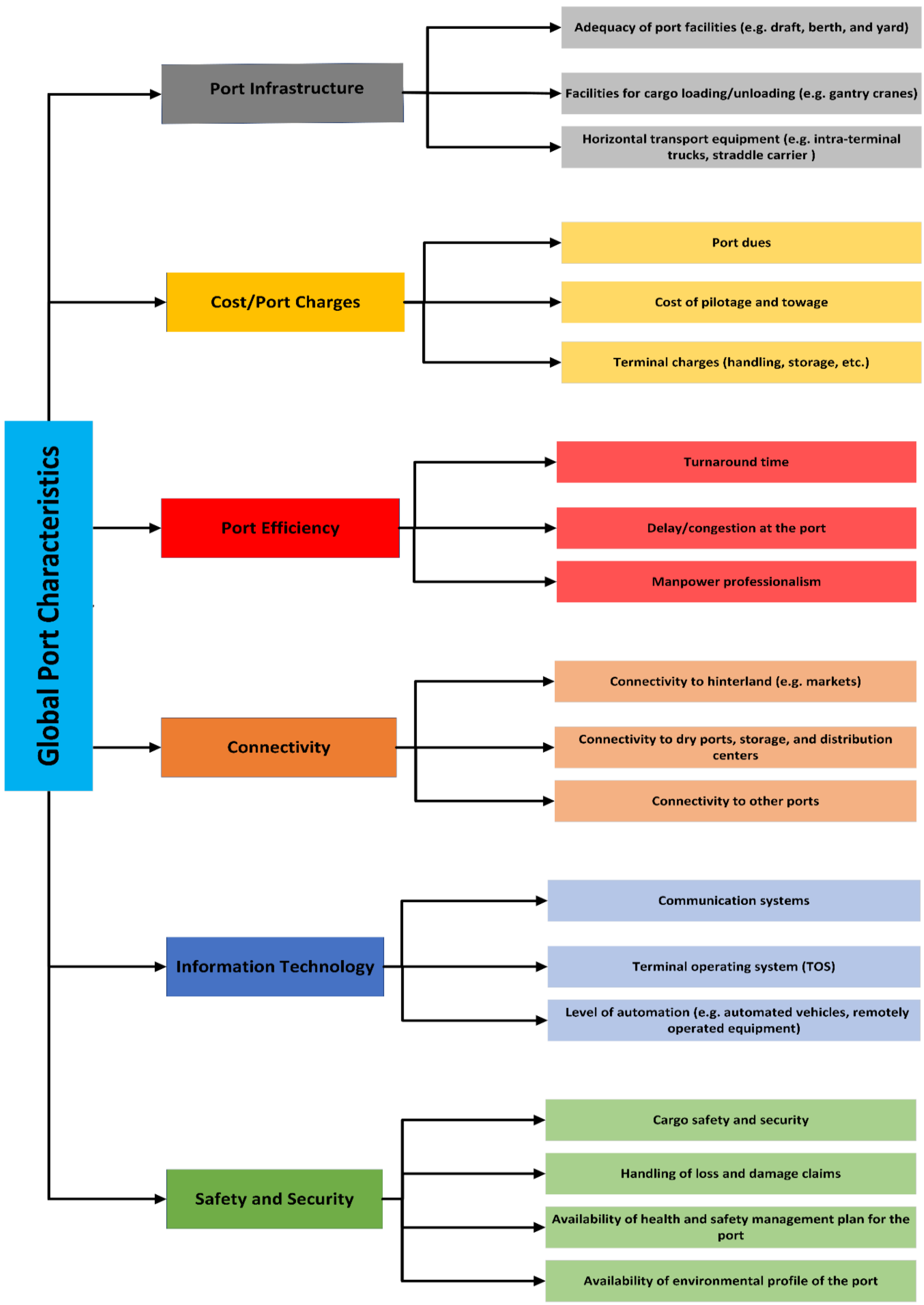

Figure 1: Port characteristics hierarchy chart AHP structured problem

3.2 Establishing the pairwise comparisons:

The scale used in the AHP method is a nominal nine-point scale starting with "equal importance," which is represented by the number 1, and ending with "absolute importance," which is represented by the number 9 [4]. It was important to describe the scale to respondents to understand how to answer the questionnaire to avoid any inconvenient answers and to ensure optimum answers to avoid a high error percentage in the results. The following table was given to the respondents.

Table 1: AHP Evaluation Scale and definition

Evaluation Scale	Definition
1	Equal Important
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very, very strong
9	Extreme Importance

After drawing the hierarchy chart and using the nominal nine-point scale, it becomes easy to start creating comparisons between the main factors and sub-factors. The next table represents a sample for the comparison tables representing a pairwise comparison between factors.

Table 2: Sample Pairwise comparison

ID	Factor	AHP SCALE																	Factor
1.	Factor 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 2
2.	Factor 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 3
3.	Factor 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 4
4.	Factor 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 3
5.	Factor 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 4
6.	Factor 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor 4

3.3 Calculation of criteria weights:

3.3.1 Create comparison matrices:

To find the relative importance between two elements/factors, the ratio for relative importance is set by using a nominal scale, and the values are 1/9, 1/8, …, 1/2, 1, 2, 3, …, 8, 9. Table (2), shows a pairwise comparison, as long the left (yellow) side of table will be constant factors and the right (blue) side is the changing factors then the next steps will be applied. If the respondent chooses a value from the right side, then the value will be projected in the main diagonal of "matrix A" as a fraction number "1/2, 1/3, ...,1/9" on the other side, if the respondent chooses a value from the (yellow) left side, it will be presented as "1, 2, 3, ..., 8, 9".

AHP method used to convert respondent choices to matrix data, the matrix is divided into two triangles upper triangle and a lower triangle.

The upper triangle in gray color in "Matrix A" is the main diagonal filled with the data first. This matrix is reciprocal matrix, elements below the diagonal will be filled second, and it will be a reciprocal values from the equivalent values. In the matrix if the factor meets itself the value will equal "1". For example: in Table (2), in first row if the respondent choose that "factor 1" has an "Extreme Importance" than "factor 2" then put "9" in the matrix, in fourth row if the respondent choose that "factor 3" has "Moderate importance" than "factor 2" so 1/3 projected in the matrix. When similar factors meets in the matrix put "1", e.g. "factor 1" meets "factor 1" the value will be "1" in "matrix A".

Matrix A=

	F1	F2	F3	F4
F1	1	9	4	7
F2	1/9	1	1/3	1
F3	1/4	3	1	2
F4	1/7	1	1/2	1

Matrix A_n=

	F1	F2	F3	
F1	0.66	0.64	0.69	0.64
F2	0.07	0.07	0.06	0.09
F3	0.17	0.22	0.17	0.18
F4	0.09	0.07	0.09	0.09

After creating the comparison matrix "A", a sum for each column is calculated to start with the next step, which is normalizing the comparison matrix by dividing each value in the matrix by the sum of the relative column, to create new matrix "A_n" after calculating the normalized matrix, for each row in the new matrix the average values calculated which give a weight (W) for each alternative which represents the eigenvector, as presented in Table (4). Now each alternative has a weight, and it can be arranged from the higher importance to the lower importance. But a consistency check is required to decide whether this judgment and weights are accepted or not, to calculate the consistency ratio CR and consistency index CI (eigenvector) of a comparison matrix A [8].

$$CR = \frac{CI}{RI} \quad (1) \qquad CI = \frac{\lambda\max - n}{n-1} \quad (2) \qquad (AW) = \text{priority matrix} * \text{criteria weight} \ (3)$$

First, create a new matrix by multiplying matrix A by the eigenvector (W), call the new matrix "AW", create the vector "λ" by dividing the elements in "AW" by the corresponding elements of (W), to calculate the maximum eigenvalue "λmax" the average of the values of "λ" will be taken. To find the consistency ratio as per equation 1. RI is a constant value related to the numbers of the factors in the matrix. If CR < 10%, then the matrix is considered to be consistent, and the judgment is accepted [8].

Table 3: Saaty's Standard Random Index (RI) Scale

Number of Decision Alternatives (n)	2	3	4	5	6	7	8	9	10	11	12	13
Random Index, RI	0.16	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.58	1.56

A consistency check should be calculated for each response individually, and the judgment that CR exceeds 10% will be re-sent to the respondent to re-answer it. In case of facing any difficulties in reaching the respondent, the response will be eliminated for the inconvenience in case it was difficult to reach the respondent. After calculating the matrices and testing the consistency for each answer separately, final step is summing the data in one final aggregate matrix. To find the Aggregation (combined results) of individual judgments for all participants, the weighted geometric mean method should be used because it reflects better the preference information in the pairwise comparison and reduces the error margin rather than using the arithmetic mean method [3]. Check the consistencies of aggregated matrices, then calculate the weights for each factor representing the total responses.

Table 4: Steps and final results to calculate CI & CR

	Weight (W)	AW	λ	λ_{max}	CI	CR
F1	0.6572	2.65	4.03	4.02	0.72%	0.80%
F2	0.0732	0.29	4.00			
F3	0.1839	0.74	4.03			
F4	0.0857	0.34	4.02			

4. RESULTS AND DISCUSSION

The main purpose of using the AHP method in this study is to know which alternatives affect the choice of shippers and shipping lines to a certain port/container terminal. The pairwise comparison tables were prepared and explained well to the respondents before starting to answer the surveys to avoid any misunderstanding and to have a lower error percentage. The survey was distributed online and through personal interviews, and the surveys were available in two languages, Arabic and English, to expand the circle of the respondents and to ease the process of the respondents. As a matter of fact, this research is concerned with the Egyptian maritime terminal ports and local terminal companies. It is preferable for some respondents to have an Arabic copy of the survey, which was a replica of the English version.

4.1 Sample size:

The surveys were distributed and sent to 50 respondents, decision-makers, port users, and experts in the maritime transport and logistics field. The experiment sample answers were diverse and included responses from different groups, which were: shipping lines, shippers, terminal operators, port authorities, researchers, scholars, and other partners dealing with shipping and port services.

As mentioned before, the survey was answered through an online version and personal interviews, only 45 responses were received back, and after the analysis stage, five responses were incomplete and inconsistency, so these answers were eliminated. As a result, the final sample size is 40 responses. The graph below illustrates the percentage of responses for each group of users:

Figure 2: percentage of responses for each group

The data in the previous figure shows that almost 57% of the answers were from the terminal operators and port authorities, and the rest of the responses were from port users like shippers and shipping lines. This ratio was almost half for each team, creating a balance in the final results.

4.2 Aggregate responses data analysis

4.2.1 Consistency Test: The table below shows the consistency tests for the 40 responses.

Table 5: consistency tests for all responses

Criterion	Test Value	Sub-Criterion	Test Value
Port Infrastructure	CI= 0.49% CR= 0.4%	Equipment availability	CI= 0.001% CR= 0.001%
		Adequacy of port facilities (e.g. draft, berth, and yard)	
		Facilities for cargo loading/unloading	
Cost/Port Charges		Port dues	CI= 0.11% CR= 0.13%
		Cost of pilotage and towage	
		Terminal charges (handling, storage, etc.)	
Port Efficiency		Turnaround time	CI= 0.23% CR= 0.3%
		Delay/congestion at the port	
		Manpower professionalism	
Connectivity		Connectivity to the hinterland (i.e. markets)	CI= 0.04% CR= 0.1%
		Connectivity to dry ports, storage, and distribution centers	
		Connectivity to other ports	
Information Technology		Communication systems	CI= 0.12% CR= 0.14%
		Terminal Operating System (TOS)	
		Level of automation	
Safety and Security		Cargo safety and security	CI= 0.23% CR= 0.4%
		Handling of loss and damage claims	
		Availability of health and safety management plan for the port	
		Availability of environmental profile of the port	

The hierarchical consistency test result of the data collected from the experts is shown in table (5). The consistency test between the main criterion (main factors), which represents the consistency between "Port Infrastructure", "Cost/Port Charges", "Port Efficiency", "Connectivity", "Information Technology", "Safety and Security" the test results were CI= 0.49% and CI= 0.4% which are less than < 10%, so it is accepted result. Moreover, the consistency test for the sub-criterion is also below the limit, which means that all the judgments accepted and the pairwise comparison matrix of the target hierarchy are sacksful, so the next step is to calculate the weight for each variable.

4.2.2 Relative weight of criteria.

Table 6: Relative weight of criteria

Criterion	Weight	Sequence	Sub-Criterion	Weight	Sequence	Overall Weight	Sequence
Port Infrastructure	14%	5	Equipment availability	0.448	1	6%	5
			Adequacy of port facilities (e.g. draft, berth, and yard)	0.338	2	5%	12
			Facilities for cargo loading/unloading	0.215	3	3%	17
Cost/Port Charges	14%	4	Port dues	0.34	2	5%	11
			Cost of pilotage and towage	0.19	3	3%	19
			Terminal charges (handling, storage, etc.)	0.47	1	7%	4
Port Efficiency	24%	1	Turnaround time	0.402	1	10%	1
			Delay/congestion at the port	0.363	2	9%	2
			Manpower professionalism	0.236	3	6%	7
Connectivity	13%	6	Connectivity to the hinterland (i.e. markets)	0.26	3	3%	16
			Connectivity to dry ports, storage, and distribution centers	0.411	1	5%	9
			Connectivity to other ports	0.329	2	4%	13
Information Technology	17%	3	Communication systems	0.299	2	5%	10
			Terminal Operating System (TOS)	0.481	1	8%	3
			Level of automation	0.22	3	4%	14
Safety and Security	18%	2	Cargo safety and security	0.343	1	6%	6
			Handling of loss and damage claims	0.189	3	3%	15
			Availability of health and safety management plan for the port	0.312	2	6%	8
			Availability of environmental profile of the port	0.155	4	3%	18

After applying the equations to calculate the element weights in different hierarchies and the consistency test for the overall 40 responses, the analyses proceed as follows: first, for the pairwise comparison matrix of the six criteria of "Port Infrastructure", "Cost/Port Charges", "Port Efficiency", "Connectivity", "Information Technology", and "Safety and Security" and the target hierarchy "The important factors that attract liners to a specific port/terminal", the weights are analyzed in (Table 6). The next graphs represent the arrangement of main factors and sub-factors. As shown in figure 3, port efficiency has the highest priority with 24%, then followed by safety and security factors, while connectivity, port infrastructure, and cost came last in the arrangement. The element weights of the criteria are multiplied by the relative weight of the corresponding elements of the sub-criteria to calculate the total weight of such elements to the target hierarchy [4]. Figure 3 shows that "Turnaround time" came first in the arrangement with 10%, followed by connectivity to other ports and communication systems. While factors like "port dues" and "Adequacy of port facilities" came last in the arrangement of the Sub-criteria sequence for overall evaluation as shown figure 4.

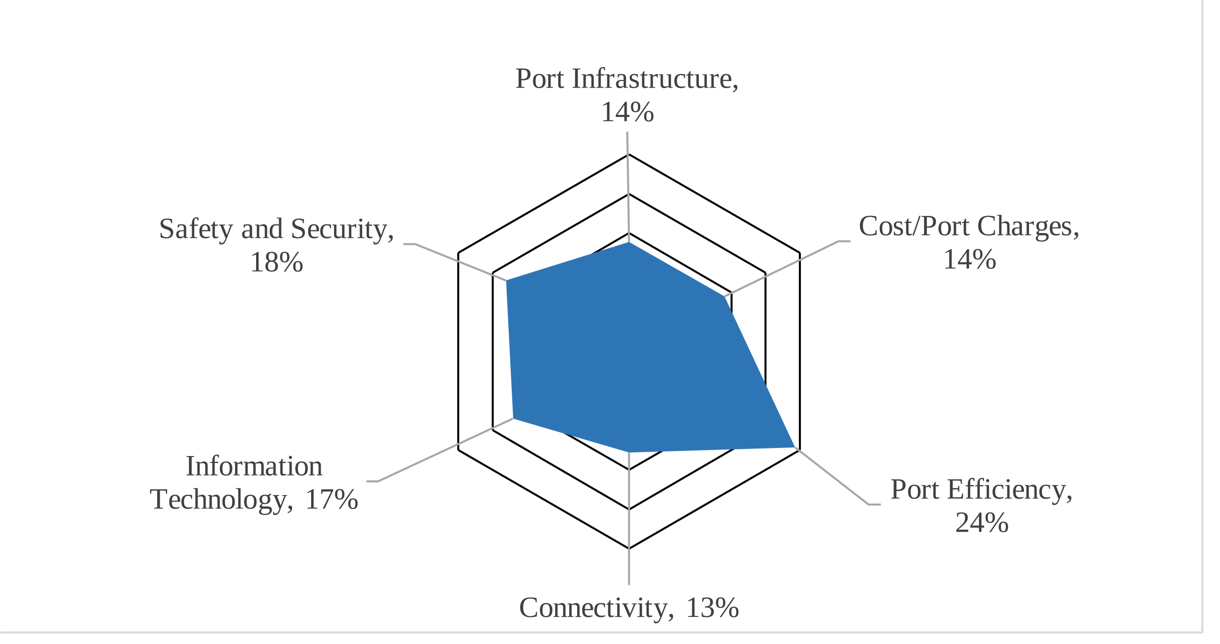

Figure 3: Main Criterion weights

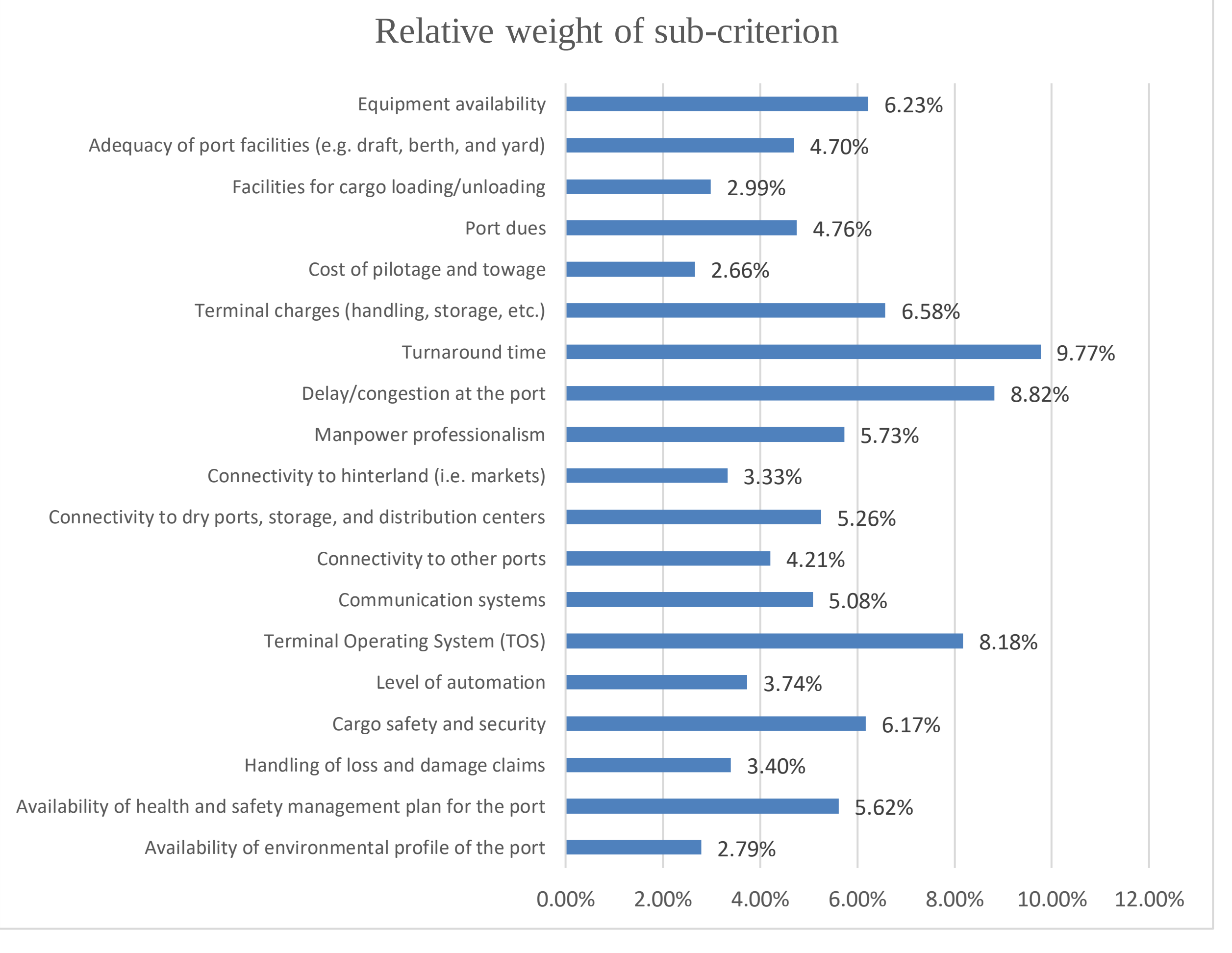

Figure 4: Sub-criteria sequence for overall evaluation

5. DATA ANALYSIS OF THE DIFFERENT GROUP RESPONSES

The study put a higher importance on creating a comparison between decision-makers (port authorities and terminal operators), and port users (shippers, shipping lines, and others (researchers, scholars, and other partners deal with shipping and port services), to find is there a gap between those two teams or they think in the same way. This balance helps to avoid any bias in results to one side over the other side.

5.1. Decision-makers (port authorities and terminal operators)

Table 7: Decision-makers (port authorities and terminal operators) data analysis

Criterion	Weight	Sequence	Sub-Criterion	Weight	Sequence	Overall Weight	Sequence
Port Infrastructure	15%	5	Equipment availability	0.488	1	7.1%	5
			Adequacy of port facilities (e.g. draft, berth, and yard)	0.295	2	4.3%	11
			Facilities for cargo loading/unloading	0.216	3	3.2%	15
Cost/Port Charges	15%	4	Port dues	0.315	2	4.6%	9
			Cost of pilotage and towage	0.14	3	2.1%	19
			Terminal charges (handling, storage, etc.)	0.545	1	8.0%	4
Port Efficiency	23%	1	Turnaround time	0.452	1	10.4%	1
			Delay/congestion at the port	0.293	2	6.7%	6
			Manpower professionalism	0.254	3	5.8%	8
Connectivity	9%	6	Connectivity to hinterland (i.e. markets)	0.255	3	2.3%	18
			Connectivity to dry ports, storage, and distribution centers	0.345	1	3.2%	16
			Connectivity to other ports	0.4	2	3.7%	13
Information Technology	18%	3	Communication systems	0.245	2	4.3%	12
			Terminal Operating System (TOS)	0.505	1	8.9%	2
			Level of automation	0.25	3	4.4%	10
Safety and Security	21%	2	Cargo safety and security	0.289	1	6.1%	7
			Handling of loss and damage claims	0.129	3	2.7%	17
			Availability of health and safety management plan for the port	0.407	2	8.6%	3
			Availability of environmental profile of the port	0.175	4	3.7%	14

For the main criterion arrangement in table 7, Port Efficiency has the highest priority with 23%, then followed by safety and security factors, while port infrastructure, cost, and connectivity came last in the arrangement. The sub-criterion table 7 shows that "Turnaround time" came first in the arrangement with 10.4%, followed by the Terminal Operating System (TOS) and Availability of health and safety management plan for the port. While factors like "Facilities for cargo loading/unloading" and "Adequacy of port facilities" came last in the arrangement.

5.2. Port users (shippers, shipping line, and others)

Table 8: Port users (shippers, shipping line, and others)

Criterion	Weight	Sequence	Sub-Criterion	Weight	Sequence	Overall Weight	Sequence
Port Infrastructure	12.5%	6	Equipment availability	0.392	1	4.90%	10
			Adequacy of port facilities (e.g. draft, berth, and yard)	0.398	2	5.00%	8
			Facilities for cargo loading/unloading	0.21	3	2.60%	18
Cost/Port Charges	12.8%	5	Port dues	0.36	2	4.60%	13
			Cost of pilotage and towage	0.273	3	3.50%	15
			Terminal charges (handling, storage, etc.)	0.368	1	4.70%	11
Port Efficiency	25.3%	1	Turnaround time	0.33	1	8.30%	3
			Delay/congestion at the port	0.466	2	11.80%	1
			Manpower professionalism	0.205	3	5.20%	7
Connectivity	19.4%	2	Connectivity to the hinterland (i.e. markets)	0.257	3	5.00%	9
			Connectivity to dry ports, storage, and distribution centers	0.5	1	9.70%	2
			Connectivity to other ports	0.243	2	4.70%	12
Information Technology	15.9%	3	Communication systems	0.382	2	6.10%	5
			Terminal Operating System (TOS)	0.438	1	7.00%	4
			Level of automation	0.179	3	2.90%	16
Safety and Security	14.1%	4	Cargo safety and security	0.393	1	5.50%	6
			Handling of loss and damage claims	0.289	3	4.10%	14
			Availability of health and safety management plan for the port	0.198	2	2.80%	17
			Availability of environmental profile of the port	0.12	4	1.70%	19

For the main criterion arrangement in table 8, port efficiency have the highest priority with 25.3%, then followed by the Connectivity factor, while port infrastructure and cost came last in the arrangement. The sub-criterion in table 8 shows that "Delay/congestion at the port" came first in the arrangement with 11.8%, followed by Connectivity to dry ports and Turnaround time. While factors like "Facilities for cargo loading/unloading" and "Availability of the environmental profile of the port" came last.

5.3 Shipping lines and port terminals

The preferences of shipping lines responses as compared to terminal operators preferred factors, shipping lines sees that port efficiency have the highest priority, followed by information technology (IT) projecting their needs for better automated ports and good communication and operating systems like (TOS), their preferable factors shows that avoiding congestion and delays are the main aspects liners looking for before choosing the port, while port dues and infrastructure came last in the arrangement. Terminal operators gave higher priority to port safety and security, then port efficiency came second followed by information technology, this arrangement is close to the preferable factors for liners. The chosen factors show that terminals operators and liners believe that fully automated ports will be the future of less congested ports.

6. CONCLUSIONS

The main purpose of this study is to find the factors that affect the choice of shippers and shipping lines of a specific port/container terminal, by using AHP method. In this study, pairwise comparisons were conducted between various variables chosen carefully by the help of the elite experts in maritime and logistics field, literature reviews, and personal interviews with experts. It was deeply believed that reducing the costs of customs, tariffs and other port dues, also, improving the infrastructure for the ports by increase the depth of the draft and extend the length of the berth also, provide more spaces for yards, will be the dominating factors. However, the aggregated results showed that "Port Efficiency" have the highest priority with 24%, which represents the time consumed in the port, and the congestion in the ports, the highest two factors in the sub-factors were "turnaround time and congestion at the port". This indicates strongly that constructing new infrastructure in the port will not solve the problem of congestion it will only delay it. As such, decision-makers need to start thinking from a new perspective to find resilient solutions for congestion, using incentives and disincentives to attract shippers to ports that have lower traffic and to reduce the congestion in congested ports. The second main factor was safety and security. This proves the researcher's point of view that port users, after the pandemic, starts to think in a different way regarding the importance of health in the port community, and more automated ports with less human interference. While connectivity, port infrastructure, and the cost came last in the arrangement. In the comparison between decision-makers and port users, the data gave hope that the future of port planning may have a better improvement because the preferable factors for both teams were close to each other both teams gave the highest priority to "port efficiency" and "information technology". Such results improve the hopes that the future of the Egyptian port terminals will have higher trading rates, as long the decision-makers are aware of market preferable changes, and nowadays a more sustainable and environmental solution is required to have a resilient port that capable of avoiding any unexpected catastrophes and of rebuilding itself again fast against any unexpected issues. To solve the issue of port congestion, which came as a top priority in this research, decision-makers need to focus on projects that support the following themes from the WPSP list: Information Technology and Health Safety and Security; as evident in data collected from both shippers/liners and operators.

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CONTAINER MOVES PER LIFT: THE IMPACT OF SPREADER TECHNOLOGY ON BAY TIME

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Keywords: containership bay size, Bay time, Gantry crane container lift, Gantry crane container moves per lift, Containership beam size, Spreader technology, Ports of call schedule, Mega containership

1. **ABSTRACT:** The trend of increasing containership size (length, beam, and draft) continues. The increase in containership size, especially beam size (bay size), increased berth and port time at a given number of lifts per hour. There are emerging technologies that allow a spreader of ship-to-shore gantry to handle multiple containers in a single lift. This paper studies the impact of the increase in the containership bay size on berth time and the role the spreader of gantry cranes can play in keeping up with the increase of bay size, thus reducing vessel port time. The paper analyzes the moves of containers per lift with different spreader technologies, where a spreader can handle one or multiple containers in one lift. The paper determines the combination of spreader technology needed to accommodate mega containerships with large bay sizes in order to reduce vessel port time. After a literature review, using the bay time determination method developed by the authors, the paper analyzes the moves per lift of different spreader technologies, vessel operations and containership bay size configurations. The analysis determines the optimal combination of equipment to comply with liner service schedules and the difficulties the equipment might pose on a marine container terminal.

2. INTRODUCTION

Containerships have been increasing in size. In 2017, OOCL launched five Triple-E[1] mega-containerships of 21,413 Twenty-foot Equivalent Units (TEU) each. For 2019, MSC and CMA CGM have on order twenty 22,000 TEU containerships. Currently, there are already sixty-six 18,000 TEU plus ships in service, and another forty-eight of 20,000 TEU plus are on order (Wikipedia, 2017). This phenomenon accentuates the continuing trend of increasing vessel size with projections of 24,000 TEU ships in 2020 (Sea Trade Maritime News, 2018).

The steady increase in orders of Triple-E class containerships is to take advantage of the economies of scale they provide at sea. As a result, pressure is rising on the ports to provide an appropriate productivity level that would discharge and load (D&L) mega-containerships quickly and efficiently within an allotted amount of time. The minimum amount of time it takes to D&L a containership depends on the containership bay size, the dominating factor of pier time, and the quay crane (QC) productivity (QC is also known as ship-to-shore container crane or gantry crane.). The larger the bay size, the more time it takes to D&L at a given QC productivity level (Yahalom and Guan, 2016). The increase in productivity levels of the QC has been very slow. The gap between the increase in QC productivity level and the increase in containership bay size is growing (Yahalom and Guan, 2017).

[1] "Triple E" is derived from "Economy of scale, Energy efficient and Environmentally improved".

Pressure mounts from carriers onto terminal operators as carriers request shorter stays at the port, and terminal operators need to improve the productivity rate in order to attract mega containerships. Currently, the QC productivity range is 25 to 38 lifts per hour. Through advancement in technology and terminal automation, the APM Terminal at Rotterdam has reached an average of 40 lifts per hour, the highest recorded in a port today (Port of Rotterdam, 2015). With respect to automation, shipping companies like Maersk are unconvinced that automation alone will increase lifts per hour as there has been no breakthrough yet that has resulted in 40 to 50 lifts per hour (Perina and Barrons, 2015). Furthermore, automation should also emphasize the increase in the number of containers moved per lift.

The quayside area of terminal operations is where port managers must invest to increase the productivity levels. The QC D&L process is the most important. QCs are limited by technology, but maximizing spreader capability would reduce the hours it takes to D&L a vessel bay. Currently, the maximum a spreader discharges is three 40ft containers or six 20ft containers per lift of the QC.

The paper discusses and demonstrates container moves per lift and their implications. A *lift* is defined as a QC spreader move to lift a single or multiple containers at once. A *move* is the number of containers a spreader can handle in one lift. For example, a spreader lifting and moving one container is a one-to-one ratio of move to lift. Whereas a spreader handling two 20ft containers and one 40ft container simultaneously would be a move-to-lift ratio of 3:1. Looking at various types of spreaders and technologies, the goal of terminal managers is to optimize spreader utilization in order to reduce the time it takes to D&L the largest bay, which is the dominating factor of pier time.

After the literature review, the methodology develops a move-to-lift ratio model given different spreader technologies in order to increase QC productivity for the largest bay at an allotted amount of time to complete the vessel operations. The conclusion identifies various spreader performances to minimize bay time, pier time and the constraints that may prohibit the QC productivity from reaching its potential.

3. LITERATURE REVIEW

The literature addressing QC performance focuses on container terminal quayside operation synchronized with the yard operation. In this respect there is indirect mentioning of quayside equipment. According to Diabat (2014), quayside is designated to allocate berths to arriving ships, and QCs are responsible for the D&L of the ships. The quality of the quayside equipment affects container throughput and handling efficiency, which in turn carries over into the yard operations. Jordan (2013) agrees with Diabat (2014) that QC productivity is a critical component of terminal productivity and may become the **limiting component** of terminal operations.

Quayside operation is the first part in managing a containership's berth time. There are several articles addressing quayside productivity, including berth and QC allocation and scheduling issues. Choo, et al (2010) analyze crane sequencing problems for multi-ships to minimize port stays using a heuristic approach based on a mixed-integer programming model. Hyongmo (2015) indicates that a mega containership should be in a container port for one day and altogether the QCs move 4,500 containers for the 18,000 TEU vessel class that is 80 percent of the quay utilization. Choo, et al (2010) look at yard congestion from high load and discharge activities.

As QC technology advances, researchers address the QC tandem lift. Choi, et al (2014) developed an operating system for the optimization of the container terminal by using tandem-lift QCs. Results show that as the tandem ratio increases, QC waiting time decreases, but yard crane waiting time increases due to an increase in quay activities. Chao and Lin (2011) studied tandem lifts for 40ft containers at Kaohsiung Port as alternates to single-lift QCs. Bartosek (2013) confirmed that QCs serve as one of the essential elements of the transshipment containers in a terminal. Yi, et al (2016) studied QC hoisting and concludes that the preference is "to use a single hoist dual spreader headblock at Yangshan Ports on the twin 40ft container QC."

Researchers study spreaders and tandem lifts. Bartosek (2013) looks at crane components and reveals future requirements for QC productivity. He and others also believe that tandem spreaders that can lift three

20ft containers or two 40ft containers are economical and more profitable. Lashkari, et al (2017) analyze the use of scheduling multi-spreader cranes that are capable of switching from multi-spreader to single-spreader modes. Huang, et al (2012) look at twinlift spreaders through a support vector machine-based fuzzy rules acquisition system.

The difficulties of implementing a multi-spreader approach deal with the variables of the stowing plan and yard congestion. Song (n.d.) looks at stow plans for each containership bay and the complexities in using multi-spreaders or single-spreaders depending on an odd or even number of rows in a bay. Choi, et al (2013) identify multiple capabilities of a spreader and how ship-to-yard vehicles must handle multiple containers in order to improve throughput of yard operations. Tierney, et al (2013) address optimizing multi-spreader productivity and stowage planning problems, while Delgado, et al (2012) describe a program that distributes containers to bay sections and slots.

The literature review did not find an explanation of spreader technology and its use in optimization of multi-lift spreader in the D&Ling of a container bay. Though articles were found regarding container stow plans, tandem QC scheduling, and multi-lift spreader use and their effects on yard congestion, no article has discussed the role of a spreader in closing the gap between bay size increase and QC productivity increase, which are the subject of this paper.

4. METHODOLOGY

Carriers seek a short and quick turnaround time in the port which is the time it takes to complete all the jobs between vessel's docking (berthing) and undocking (un-berthing). The dominating turnaround factor on board the containership is the bay size.

The methodology starts by describing the bay time principle that is based on the bay size and QC productivity and continues with a detailed description of several QC productivity issues, ratio of moves per lift and its critical technological components. The methodology completes with a determination of an effective productivity level and its associated technology that keeps a liner service on schedule.

4.1 Bay time

Bay time is defined as the amount of time it takes to D&L the largest fully loaded bay of a containership (Yahalom and Guan, 2016). From Yahalom and Guan (2017), "Containership bay time is determined by containership bay holding capacity (or size) (B_i) and quay crane productivity (lifts per hour) (P) (Yahalom and Guan, 2016). Since a bay is D&L'd, bay time is two times the time it takes to only discharge or load a bay, counting every container move separately and as one lift each (Equation 1).

$$B_{it} = \frac{2B_{ic}}{P} \qquad (1)$$

Where:

B_{it} is bay time (in hours).

B_{ic} is the number of containers (20ft and/or 40ft) in a bay, multiplied by 2 due to D&L.

P is quay crane productivity measured in container lifts per hour."

The time it takes to D&L a bay is a function of the bay size and QC productivity. The larger the bay, the more time it takes to complete D&Ling the entire bay and a vessel at a given QC productivity level (Yahalom and Guan, 2016, 2017). The larger the QC productivity, the less time it takes to completely D&L a bay, which is this paper's focus.

4.2 Productivity characteristics

The D&L bay time determination is complex. It depends on several QC operation variables, divided into four categories: D&L operations (together and separately), QC operator's skills, QC operation technology used and container terminal contracts with vessel owners/operators. Each of these categories impacts QC productivity differently. Equation 2 is a modification of equation 1, taking into account these characteristics as follows:

(2) $$B_{it} = \frac{BD_{ic}}{P.r.t.d} + \frac{BL_{ic}}{P.r.t.d}$$

Where:

$2B_{ic} = BD_{ic} + BL_{ic}$ is the number of containers (20ft and/or 40ft) D&L'd in a bay. The D&L operation is separated to discharge (D) and load (L).

P is quay crane productivity measured in container *lifts per hour*.

r is the ***ratio*** of the average number of containers *moved per lift*.

t is a *coefficient of utilization* of the theoretical productivity.

d is a *coefficient* of *dual cycle,* taking into account dual cycle operations productivity.

Bay time could be subject to all or some of the variables identified in equation 2. Several of the variables are self-explanatory.

The moves-per-lift ratio (r) is a QC productivity measure indicating the theoretical average number of containers *moved per lift* (Equations 2 and 3). The ratio is the basis for determining the needs for performance enhancement.

(3) $$r = \frac{M\ (Number\ of\ containers)}{L\ (one\ lift)}$$

A ***lift*** (L) is defined as a simple QC spreader pickup of a container(s) to discharge or load. For example, a lift could be one container or a block of six containers. In either case, it is one lift. A ***move*** (M) is the number of containers a spreader can handle (move) in one lift. From the aforementioned, for a lift of one container, M = 1, and for a lift of six containers, M = 6. The r's average ratio in equation 2 is one or larger (r ≥ 1).

- r = 1 is the most common operation of moving one container at a time. Historically, for a containership with a small number of D&Ls, one lift is equal to one move (L = M). This operation is usually with a spreader designed to move a single container, which is also the operation's *baseline*.
- r > 1 is an operation based on moving multiple containers per lift. This measure is applied to dual cycling and advanced spreader technology.

The *coefficient of utilization* (*t*) addresses the deficiencies of QC multi-container D&L operations due to technologies such as twinlift, triple-lift, quatro-lift, hexa-lift (six) and their combinations. A multi-container operation takes more time to lock containers to both the spreader on board a vessel and quay when placing containers on a flatbed, compared to a single container D&L operation. The added time is due to technology adjustment, sometimes per lift, and slower hoisting and trolling of the D&L operation. Since the moves per lift (r) are theoretically associated with the spreader technology (twinlift: r =2, triple-lift: r = 3, and quatro-lift: r = 4), the operating productivity t is reported at 70 percent of the one-container-per-lift operation. This average coefficient could also include the occasional system failure time (Bartosek and Marek, 2013). Furthermore, one can also expect a non-linear relation of the coefficient of utilization; with an increase in r, the utilization could be smaller, for example, when r = 4, t = 65 percent.

The *Coefficient of dual cycle* (*d*) operation refers to a QC moving two containers in each cycle, discharging an import container and loading an export container on the return trip to pick up the next import container. A dual cycle operation, which is feasible only below deck and not for all tiers, turns an empty trolley crane move into a more productive move, doubling the number of containers moved in one cycle. Through their research Goodchild and Daganzo (2006, 2007) demonstrate that QC dual-cycle productivity can increase overall D&L operations by 10 percent.

The pressure on terminal operators to move multiple containers is common in large or busy marine container terminals. The pressure is driven by competition and turnaround time specifications in the contracts, especially when vessels are large and the existing technology is inadequate to complete the D&L operation on time. However, the multiple container moving operation has its limits because, presently, it is feasible only for (1) dual cycle operation below deck and for (2) twinlift operation when discharging a bay. Therefore, what is a sufficient r for completing a bay on time?

5. BAY SIZE AND QC PERFORMANCE

Bay size determines the number of containers for D&L in a containership. The larger the bay, the more containers are stored and moved. Frequently a bay is separated by a hatch cover between the above and below decks. For example, a Triple E containership's largest bay could store above deck 230 40ft containers (23 rows x 10 tiers) and below deck 174 40ft containers (22 rows x 8 tiers - 2) or a total of 404 40ft containers. Other Triple Es design the largest bay with 396 40ft containers. For subsequent illustrations a bay size of 396 40ft containers is used.

The evolution of bay size increase and QC productivity increase (lifts per hour) over the last 20 years is not synchronized. For example, the increase in containership bay size since the launching of the Panamax vessel class some 20 years ago was 202 percent (from the Panamax's 131 40ft containers per bay to the Triple E's with 396 40ft containers per bay). The increase in QC single lifts per hour in the last 20 years was 90 percent (from 20 to 38 lifts per hour). These two trends resulted in a gap between them of 112 percent (Yahalom and Guan, 2017 and Figure 1 reproduced from the study). The persistent gap is recognized by the industry which is challenging terminal operators to handle 6,000 containers in a 24-hour period (van Marle, 2015).

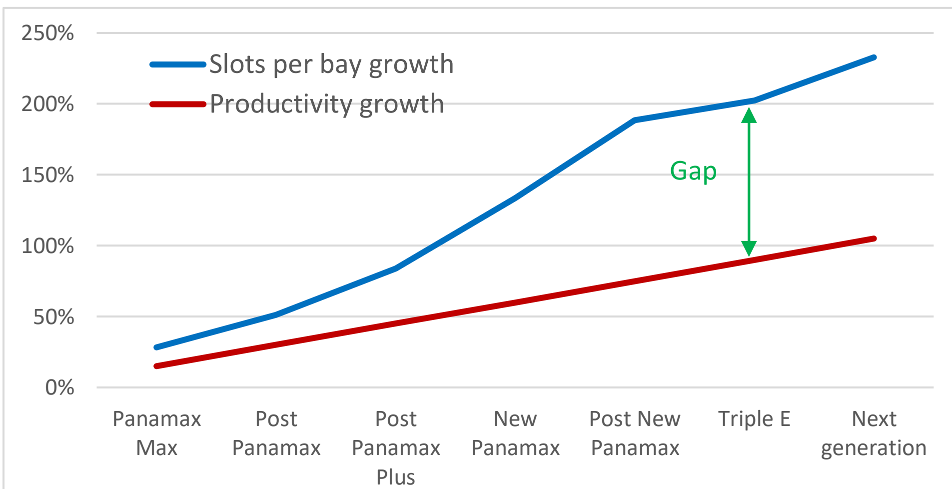

Figure 1: Slots per Bay Growth and Productivity Growth

The gap can be closed by using a combination of an increase in each of the QC operation alternatives such as: lift per hour, dual cycling, various advanced spreader technologies, Fastnet technology (on the drawing board) and others (Soderberg, et al, 2016). Management tools that increase productivity include sophisticated computer programs for interface handling of containers between the quay and the yard, including stowing plans, plans for dual cycling, sophisticated spreaders automation features and pick-up by appointment. In short, in the effort to improve efficiency and productivity, the container terminal management has to overcome many obstacles and challenges, some of which are costly technologies.

6. GAP ANALYSIS

Closing the gap between bay size increase and QC lifts per hour increase (Figure 1) is effective productivity. *Effective productivity* is defined as the number of *moves per hour*, which close the gap created by the increase in the containership's largest bay size in order to complete a bay at an allotted amount of time. Obviously, containerships of different bay sizes require a different number of moves per hour using a mix of D&L tools identified above.

- Assuming an allotted 20 hours to complete the largest bay (Table 2), an analysis of the different vessel classes indicate that the Triple E requires a minimum of 39.60 lifts per hour (792/20) to D&L the largest bay of 40ft containers. A mixed bay of 20ft (40 percent) and 40ft (60 percent) containers requires 55.44 lifts per hour (1,109/20).

- Assuming a QC average of 35 lifts an hour (Table 1), the D&L of the largest bay of 40ft containers of a Triple E takes a minimum of 22.63 hours to complete. Furthermore, every increase in vessel class added 36 to 144 containers (88 average) and 1.03 to 4.11 hours (2.5 average) to the D&L time (from Table 1). The D&L of the largest mixed container bay (20ft and 40ft) for the New Panamax, Post New Panamax and the Triple E vessel class, takes more than 20 hours to complete. As before, an increase in vessel class added 51 to 201 containers (124 average) and 1.46 to 5.74 hours (3.5 average) to the D&L time (from Table 1).

In short, both cases indicate that the number of moves per lift is larger than one (r > 1), where the total time to D&L a 40ft bay is less than 20 hours.

Table 1.Lifts per hour required to D&L a containership in 20 hours and the number of hours required to D&L the largest bay at 38 lifts per hour

	40ft container			Mix of 40% 20ft and 60% 40ft containers		
Vessel class	Number of containers for D&L	Minimum lifts per hour in 20 hrs	Minimum number of hours with 35 lifts per hour	Number of containers for D&L	Minimum lifts per hour in 20 hrs	Minimum number of hours with 35 lifts per hour
Panamax	262	13.10	7.49	367	18.34	10.48
Panamax Max	336	16.80	9.60	470	23.52	13.44
Post Panamax	396	19.80	11.31	554	27.72	15.84
Post Panamax Plus	482	24.10	13.77	675	33.74	19.28
New Panamax	612	30.60	17.49	857	42.84	24.48
Post New Panamax	756	37.80	21.60	1,058	52.92	30.24
Triple E	792	**39.60**	**22.63**	1,109	**55.44**	**31.68**

A 10 percent increase in productivity due to dual cycling closes the gap for the Triple E bay of 40ft containers (35 x 1.10 = 38.5 moves per hour where the required average lifts per hour is only 39.6). But the 10 percent increase in productivity of dual cycling is still inadequate in closing the gap for the mixed container bays for the New Panamax, Post New Panamax and the Triple E vessel class (Table 1).

Multiple container moves with every QC lift, such as twinlift spreader technology (tandem or abreast), would close the gap. For example, the potential number of container moves of a twinlift spreader handling two containers in every lift (r = 2) at an average rate of 35 lifts per hour, in 20 hours is 1,400 containers (2 x 35 x 20). Therefore, the Triple E mixed bay of 1,109 containers requires that 79 percent (1,109/1,400) of its containers be D&L by twinlift spreaders to complete the largest bay on time (Twin lifting the entire bay takes 15.84 hours = 1,109/(2 x 35)) (Table 2 and Figure 3). Obviously, the smaller the number of average lifts per hour, the larger the number of twinlift operations required. However, at 70 percent twinlift operation efficiency, the potential number of containers moved in 20 hours is only 980 (1,400 x 0.70), which indicates that the entire bay should be a twinlift operation.

Table 2 and figures 2 and 3 illustrate the performance outcomes of various lifts per hour. They indicate that a vessel's QC D&L operation at a low lifts per hour rate with twinlift spreaders always generate higher moves per hour. The benefits of using twinlift spreaders are especially important when the ratio of twinlift operations is larger than 0.50. Because a 0.50 twinlift operation is equivalent to the baseline of r = 1 operation with a single spreader of one container per lift, which is also the minimum required operation ratio to stay on time.

Table 2. Twinlift D&L operation ratio in order to complete the largest bay in 20 hours

Vessel class	40ft containers (lifts per hour)					Mixed 20ft and 40ft containers* (lifts per hour)				
	Number of containers	30	35	38	40	Number of containers	30	35	38	40
Panamax	262	0.22	0.19	0.17	0.16	367	0.31	0.26	0.24	0.23
Panamax Max	336	0.28	0.24	0.22	0.21	470	0.39	0.34	0.31	0.29
Post Panamax	396	0.33	0.28	0.26	0.25	554	0.46	0.40	0.36	0.35
Post Panamax Plus	482	0.40	0.34	0.32	0.30	675	0.56	0.48	0.44	0.42
New Panamax	612	0.51	0.44	0.40	0.38	857	0.71	0.61	0.56	0.54
Post New Panamax	756	0.63	0.54	0.50	0.47	1,058	0.88	0.76	0.70	0.66
Triple E	792	0.66	0.57	0.52	0.50	1,109	**0.92**	**0.79**	**0.73**	**0.69**

*40% of 20ft and 60% of 40ft containers

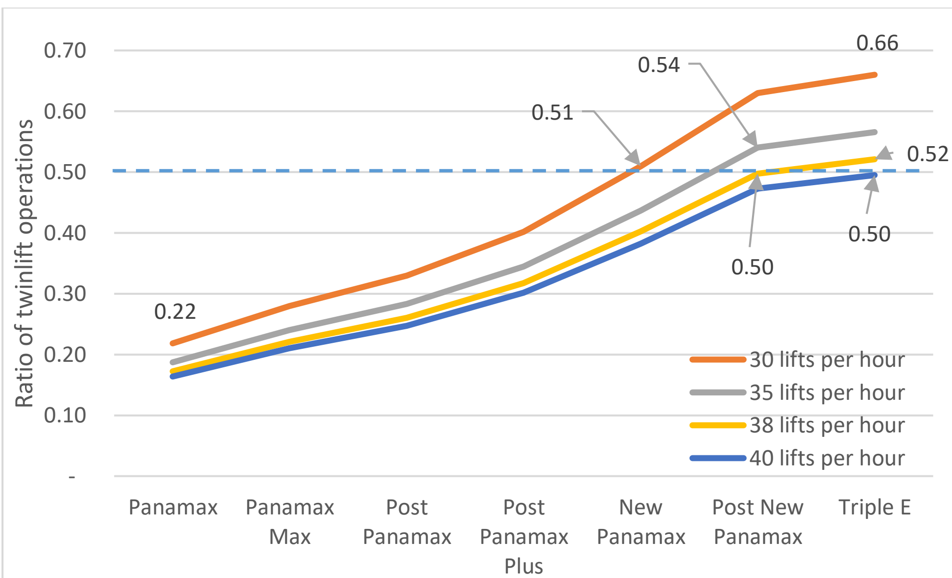

Figure 2: Twinlift Operation Ratios for a 40ft Container Bay

The ratios of QC twinlift D&L operations of the largest bay of 40ft containers at different lifts per hour (Table 2 and Figure 2) indicate that the Triple E equals one container per lift only at 40 lifts per hour rate (0.50). The others fall behind and require exstensive twinlift operations.

A D&L operation of a mixed bay of 20ft and 40ft containers requires twinlifts to be completed in 20 hours. For instance, the Triple E at 30 lifts per hour requires that 92 percent [1,109/(30 x 20 x 2)] of the QC operation be twinlift. A QC with 40 lifts per hour requires a twinlift of only 69 percent of the operation (Table 2 and Figure 3). In short, four classes of vessels require twinlift operations in an allotted 20 hours.

A twinlift operation could handle a maximum of four 20ft containers (tandem and abreast). Applying this number of moves per lift (r = 4) reduces the time even further. Clearly, a three 40ft container operation and its combinations (tandem and abreast) will complete D&Ling a bay faster than one container per lift. Still, a dual lift D&L operation (d = 0.10) at 70 percent capacity (t = 0.70) would be slower (Table 1).

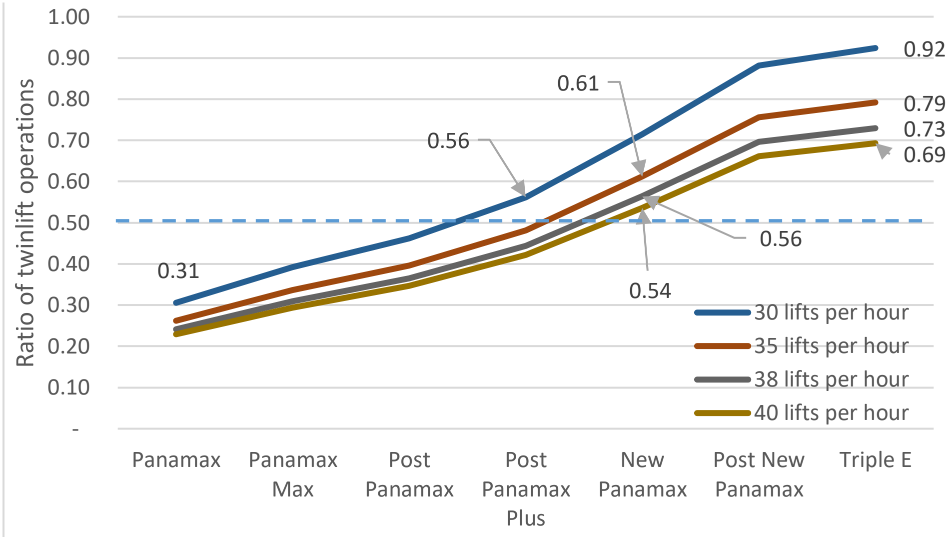

Figure 3: Twinlift Operation Ratios for a Mixed Bay of 20ft and 40ft Containers

Bay time also depends on the number of bays blocked by a QC. As indicated before, with the existing technology the standard QC physically blocks two bays. Therefore, when a QC serves two adjacent bays, it takes double the amount of time it takes to D&L one bay in anyone of the outlined scenarios above.

7. PRODUCTIVITY IMPROVEMENT ALTERNATIVES AND ILLUSTRATIONS

Containership D&L operation's schedule is based on QC productivity. The larger the productivity, the shorter the bay time, berth time and port time. In order to be competitive, container port managers improve productivity by resorting to a combination of managerial tools and technologies.

Equation 2 illustrates the inverse relationship between QC productivity and bay time. Bay size (B_{ic}) is constant per vessel and frequently within vessel class. Therefore, a container terminal with a contractual obligation to complete a containership within a given amount of time (hereinafter bay time of 20 hours) must increase it QC productivity (*P and r*) as the vessel's bay size increases with the deployment of wider containerships. For example, the Triple E containership with 396 40ft containers in the largest bay increased from the 378 40ft containers in the largest bay of the Post New Panamax containership vessel class. Thus, in order for a container terminal to fully D&L the Triple E new bay size and maintain a 20 hour bay time, the productivity level had to increase from an average of 37.8 (378 x 2/20) moves per hour to an average of 39.6 (396 x 2/20) moves per hour. The average two additional moves per hour can be achieved in multiple ways frequently by spreader technology that determines how many containers a spreader moves in one lift. Advanced spreader technology moves multiple containers in one lift. Using equation 2, r takes various values depending on spreader and operation technologies.

7.1 Single lift operation (baseline)

Container operations start with a single container lift. The simplest D&L operation is to lift one container at a time (import or discharge container) and return the spreader empty for the next discharge. In terms of equation 2, r = 1, assuming t = 1 and d = 1, therefore, $B_{it} = 2B_{ic}/P$.

Presently the global range of D&Ling operations of a single lift per hour is between 33 and 38. For instance, a single lift operation of D&L of a bay of 792 40ft (396 x 2) containers at a productivity level of 35 lifts per hour takes 22.6 hours (792/35). Furthermore, since a standard QC blocks two bays, it takes 45.2 hours to complete two adjacent bays.

Bays are frequently stacked with a mix of 20ft and 40ft containers. Therefore, the amount of time it takes to D&L a mixed bay is larger. For instance, a split bay with 40 percent of 20ft containers and 60 percent of 40ft containers takes 31.7 hours to D&L [(792 x 0.4) x 2 + (792 x 0.6) = 1,109/35] or 63.4 hours for two adjacent bays, an additional 40 percent compared to a bay with the same size containers.

Ports that require safety margin and/or interference avoidance in their operation add space between QCs that blocks additional bays (OECD/ITF, 2015) and requires additional time to complete adjacent bays. One and two additional bay blockages increase bay time to 67.8 hours and 95 hours, respectively, in the two aforementioned examples. Furthermore, Hyongmo (2015) calculates that the maximum number of QCs per containership should be one QC per about 50 meters (164ft) of the vessel's length (LOA), thereby blocking four bays. Reaffirming this ratio is the practice of deploying eight QCs per 400 meters of the vessel's length and, again, the perception that vessel length is the dominating factor (van Marle, 2015) where actually the vessel's beam is the dominating factor, not the vessel's length, in determining bay time and berth time (Yahalom and Guan, 2016, 2017).

The large amount of time it takes to D&L wide containerships is not competitive and not acceptable to the container port customers. QC developers seek to increase QC productivity in order to reduce bay time and consequently berth time and port time.

7.2 Single lift and dual cycle operation

The most economical method (operating with existing equipment and a sophisticated crane/yard operating system) to increase QC productivity and reduce the bay time gap is by using a dual cycle operation (Goodchild 2005; Goodchild and Daganzo 2006; Goodchild and Daganzo 2007; World Caro News 2007; Zhang and Kim 2009; also called "dual command cycle operation" by Kim and Lee, 2015). Testing dual cycling confirmed a 10 percent productivity improvement and in one instance a 30 percent improvement (World Caro News 2007). In terms of equation 2, d = 1.10, r = 1 and t = 1 or 0.70.

For example, applying the 10 percent productivity increase due to dual cycling (d = 1.10, r = 1 and t = 1) to the two aforementioned, reduces the bay time from 22.63 hours to 20.57 hours [792/(1.1*35)] for the same container size per bay and from 31.7 hours to 28.8 hours [1,109/(1.1*35)] for a mixed containers per bay of 20ft and 40ft, respectively. Furthermore, since dual cycling productivity improvements are for the entire operation, the aforementioned figures are not subject to utilization constraints (t) of 70 percent. However, given the large gap indicated above (Figure 1), dual cycling is not enough to close the indicated gap.

7.3 Advanced spreader technology

Advanced spreader technology, increases QC productivity, are spreaders that discharge multiple containers in one lift abreast (side-by-side) and/or in tandem (one-after-another). At the present time, due to technological limitations, multiple container moves are <u>only for discharge operations</u>. We expect future multiple container moves for load as well. Multiple containers per lift include: a *twinlift* (tandem, abreast or vertical, also called Vertical Tandem Lift - VTL), *triple spreader* (three-lift in various abreast and tandem combinations), *quadruple lift* (in various abreast and tandem combinations), *BLOK-BEAM* spreader technology handles six empty containers in a block of three horizontally and three more below (r = 6) (Louppova, 2016; MAREX 2016), *SINGA Port* (Jiang, et al 2015) envisions an operation with a "triple hoist quay crane with tandem lift. The quay crane can achieve 38 moves per hour and move 152 TEUs per hour" and others (Lind, et al 2007; ZPMC n.d.; Louppova 2016; MAREX 2016). Hay (2016) reports 60 containers move per hour.

7.4 Multiple lift operation

The most common multiple container lift used is the twinlift abreast (twin-40). Twinlift spreaders increase efficiency and versatility. A twinlift spreader can discharge four TEUs per cycle (two 40ft containers abreast, four 20ft containers abreast, tandem or 12 containers abreast, tandem combinations) with a single set of controls and operator (Johansen, 2007).

Many container terminals separate the discharge and load of a twinlift operation. After the discharge operation is completed, the load operation starts. In terms of equation 2, presently: the *discharge* rate could be r = 2, 3 or 4. The *load* operation is one container per lift, r = 1 (assuming d = 1 and t = 1).

For instance, assuming a flawless operation (d = 1 and t = 1) of a twinlift 40ft spreader that fully discharges a Triple E bay by lifting in every discharge two 40ft containers (r = 2) and loading one container at a time at 35 lift per hour, it takes 16.97 hours [396/(2 x 35) + 396/35] to complete D&Ling of a bay of 396 40ft containers; discharge of r = 3 takes 15.09 hours and for r = 4 it takes 14.14 hours (Table 3, line 3). Thus, effectively, the overall multiple discharge operation reduces the total number of trolley trips ratio to r = 1.5, 1.33 and 1.25, respectively (Table 3, line 6). A QC operation of two adjacent bays will double these figures.

The probability of a flawless multi spreader operation throughout the entire bay (t = 1) is very small; therefore, the actual amount of time to D&L a bay of 40ft containers is larger. At an operating productivity of 70 percent (t = 0.70), the aforementioned will be 24.24 (16.97 x 1/0.70), 21.54 and 20.2 hours, respectively (Table 3, line 4). However, with dual cycle (d = 0.10) the number of hours decline to 22.04 (24.24/1.1), 19.59 and 18.37, respectively (Table 3, line 4a). A mixed bay at 70 percent efficiency will generate bay time of 30.87, 27.45 and 25.73 hours, respectively (Table 3, line 4a). Applying this methodology to all vessel classes indicates that presently a bay with 40ft containers of the Post New Panamax and the Triple E will take more than 20 hours to D&L with twinlifts of 35 lifts per hour but triple and quatro lifts will put the bay time operation below 20 hours (Figure 4).

Table 3. The number of hours to D&L a Triple E containership using multiple lift operation

Activity	# of Boxes	Container size 40ft				# of Boxes	20ft and 40ft			
		Spreader technology					Spreader technology			
		Single lift	Twin-lift	Triple-lift	Quatro-lift		Single lift	Twin-lift	Triple-lift	Quatro-lift
Design moves per lift (r)		**1**	**2**	**3**	**4**		**1**	**2**	**3**	**4**
Present										
1. **Discharge** time (multiple lifts)	396	11.31	5.66	3.77	2.83	555	15.86	7.93	5.29	3.96
2. **Load** time (single lift)	396	11.31	11.31	11.31	11.31	554	15.83	15.83	15.83	15.83
3. Total Time (hours)	792	**22.63**	**16.97**	**15.09**	**14.14**	1109	**31.69**	**23.76**	**21.11**	**19.79**
4. Coefficient of utilization (t=0.70) hours		**NA**	**24.24**	**21.55**	**20.20**		**NA**	**33.94**	**30.16**	**28.28**
4a. (d=0.10) + (t=0.70) hours			**22.04**	**19.59**	**18.37**			**30.85**	**27.42**	**25.71**
5. Ratio of multiple lift to single lift		1	0.75	0.67	0.63		1	0.75	0.67	0.62
6. Actual number of trolley trips (r)	792	2	1.5	1.33	1.25	1109	2	1.50	1.33	1.25
Future										
7. Future D&L time	792	**22.63**	**11.31**	**7.54**	**5.66**	1109	**31.69**	**15.84**	**10.56**	**7.92**
8. Ratio of multiple lift to single lift		1	0.50	0.33	0.25		1	0.50	0.33	0.25
9. Dual-cycle coefficient (d=0.10)	792	20.57	10.78	7.30	5.52	1109	28.81	15.09	10.22	7.73
10. Coefficient of utilization (t=0.70)	792	NA	16.16	10.78	8.08	1109	NA	22.63	15.09	11.32
11. (d=0.10) + (t=0.70)	792	NA	15.39	10.43	7.88	1109	NA	21.55	14.60	11.04

Similarly, a mixed bay of 20ft and 40ft containers will presently take more time to D&L at the same conditions. At mixed bay dual cycle operations at 35 lifts per hour and 70 percent productivity, even at a quatro lift, is not enough to obtain a bay time of 20 hours. The vessels class that are affected include the Post Panamax, New Panamax, Post New Panamax and the Triple E (Figure 5).

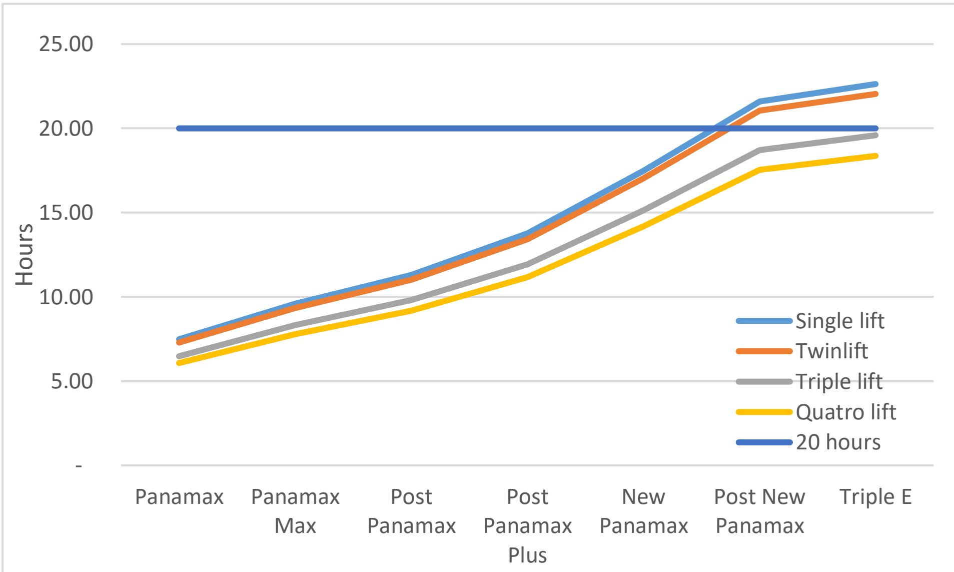

Figure 4: Present D&L Time of 40ft Container Bays at 35 Lifts per Hour Dual Cycle and 70 Percent Productivity

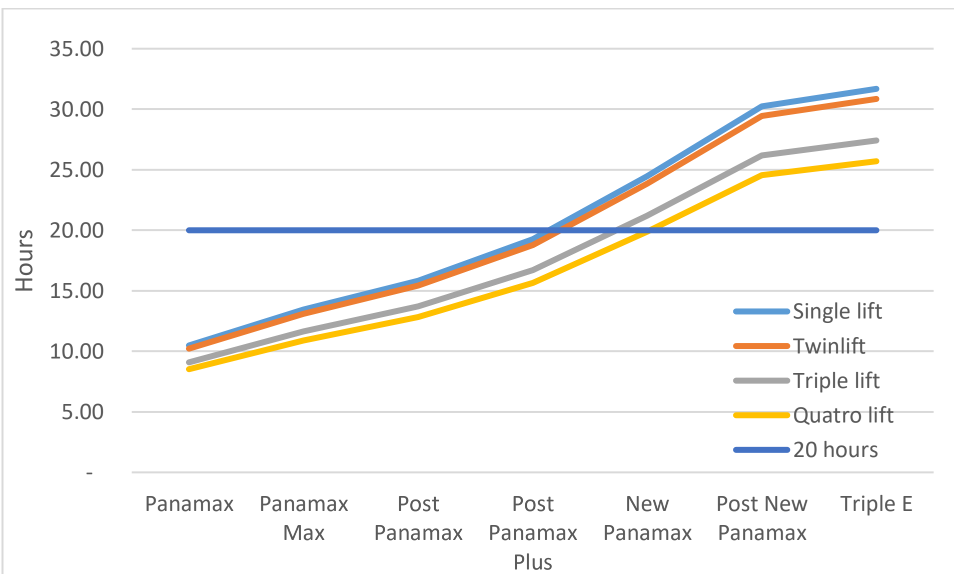

Figure 5: Present D&L Time of Mixed Container Bay at 35 Lifts per Hour Dual Cycle and 70 Percent Productivity

The future aforementioned advanced twinlift spreader operation is expected to be of multiple containers in every D&L.

- In terms of equation 2, r = 2, 3, and 4, d = 1 and t = 1. The operation times are 11.31, 7.54 and 5.66 hours respectively and the overall operation is reduced by 1/2, 1/3, and 1/4, respectively (Table 3, lines 7 and 8), which is time efficient compared to the contemporary operation system.
- Advanced spreader technology and dual cycle operation provide additional operation efficiencies. In terms of equation 2, assuming d = 0.10, the r's are: twinlift r = 2.1, triple lift r = 3.1 and quadruple lift

r = 4.1. The corresponding amounts of time to D&L a 396 container bay are 10.78, 7.30 and 5.52 hours, respectively (Table 3, line 9).

- But, with a likelihood of only 70 percent operation efficiency (t = 0.70), the aforementioned figures are 16.16 (11.31 x 1/0.70), 10.78 and 8.08 hours, respectively (Table 3, line 10).
- Finally, the aforementioned with dual cycling (d = 0.10) and partial utilization (t = 0.70) the operation takes 15.39, 10.43 and 7.88 hours, respectively (Table 3, line 11).

The future D&L operation, by fully twin-lifting a bay, is expected to be achieved in stages starting a full twinlift below deck before reaching a total twinlift operation.

The number of twinlift spreader operations of QC trips depends also on the mix of 20ft and 40ft containers in a bay. The twinlift technology is versatile and could lift 12 combinations of 20ft and 40ft container configuration. Table 3 illustrates the time it takes to D&L a Triple E bay of 396 mixed containers of 40 percent 20ft containers and 60 percent 40ft containers. The illustration is parallel to the 40ft container case. The comparison highlights that it takes 40 percent more time to D&L a mixed bay across the board when compared to a single bay D&L operation. However, it also indicates that twinlift and triple lift in every lift will close the gap and keep a bay time D&L operation at 20 hours or less.

8. CONCLUSIONS AND RECOMMENDATIONS

Completing D&Ling the largest bay, which is the dominating factor, of very large containerships in an allotted amount of time is a container's port industry challenge. The gap between containership bay size growth and QC lifts per hour growth is growing with every launch of a new containership class.

The gap is recognized by the port industry and its technology providers. Multiple solutions and tools were developed to D&L the largest bay in order to increase QC moves per hour that will keep a containership at the port for the minimum amount of time.

This paper has developed an *effective productivity* concept that calculates the number of moves per hour needed to complete D&Ling the largest bay on time using multiple D&L technologies and operation processes. Since every container terminal and containership are different, it is not possible to prescribe a uniform solution to close the gap. Every terminal is designed differently and uses different equipment, the equipment operators have different skills, and the contractual agreement addresses allotted time differently. However, within the variety of solutions presently available, advanced spreader technology and dual cycling, in this order, dominate.

Presently, due to operation limitations and technological and operations constraints, the QC operations, on very large containerships, are not able to comply with the contractual allotted time. The paper demonstrates that a mixed bay of 20ft and 40ft containers in large containerships (Post Panamax Plus, New Panamax, Post New Panamax and Triple E) takes more than 20 hours to D&L the largest bay using a single lift operation, and that with every increase in containership class the average number of hours of D&L increased by 3.5 hours. Multiple spreader operation at 70 percent productivity and dual cycling improve performance, but it does not close the gap. As a result, containerships are delayed and shipping lines call multiple ports in a voyage.

In the future, container terminals are expected to gradually accommodate the vessels by overcoming the present limitations and constraints associated with the vessel (no hatch) and container yard operations (a QC per bay). Other expected improvements in the D&L operations include: an increase in the number of lifts per hour from 38 to 50 per hour, an increase in spreader operations efficiency from 70 to 90 percent and an increase in dual cycling efficiency from 10 to 50 percent. These performance improvements require investments in advanced spreaders capable of multiple container lifts, invest in new QC per bay technology (such as "Fastnet"), monitor system operations to increase dual cycling, and overall improve operations synchronization. These measures will increase the move-to-lift ratio and vessel turnaround time quicker.

Future research should concentrate on accommodations' challenges of new technologies such as spreaders, vessel design (especially beam size), methods to close the operations gap (operation systems analysis and synchronization analysis), and the determination of the right mix of equipment.

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Brief Biography for the Presenter

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Hydrodynamic analysis of ship manoeuvrability at ports using CFD

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Keywords: CFD, Reynolds-Averaged Navier-Stokes equations solver, Ship maneuverability, Restricted waters

1. ABSTRACT: The way a ship moves in restricted waters is significantly different from how it moves in open waters due to the impact of limited depth conditions. This is because ships often operate in shallow water areas like ports or harbours. To understand these effects on ship manoeuvrability, the manoeuvrability of the KRISO Container Ship (KCS) model was studied at ports using unsteady Reynolds-Averaged Navier-Stoked computations combined with 6 degree-of-freedom (DOF) rigid body motion equations. The study used an adaptive dynamic mesh approach to allow the vessel to move freely and for the rudder to be controlled. Simulation tests were performed at ports modelled as restricted waters with varying water depth to draft ratios, and results were partially validated with experimental data. The findings showed that the ship's forward movement, lateral movement, and tactical diameter increased as the water depth to draft ratio decreased, linked to the complex interactions between the hull wake, boundary layer, propeller, vortex, and bottom of the seabed.

2. INTRODUCTION

The growing size of ships has highlighted the need to understand how they maneuver in shallow water (Tezdogan et al., 2016). Navigation in shallow water is common for ships, especially when approaching harbors or ports. Some nearshore and open-sea areas can also be considered restricted water regions with limited depth of the water. Proper decision-making about ship maneuvering actions requires a good understanding of a ship's maneuverability in shallow water by those in charge of navigation safety. However, available information on ship maneuvering is usually limited to deep water, obtained through full-scale sea trials or model-scale experiments, in compliance with International Maritime Organization (IMO) standards. Although these provide information on a ship's maneuverability in deep unrestricted water, they do not offer practical insights into maneuvering in shallow water, which can differ significantly. This study aims to address this gap by investigating ship maneuvering performance in restricted waters such as ports using an unsteady Reynolds-Averaged Navier Stokes (URANS) method.

In this work reported in this paper, the turning ability of the KRISO Container Ship model in restricted water ports is analyzed. The focus is on the maneuvering indices and hydrodynamic loads related to the turning movements. The study also evaluates the various hydrodynamic phenomena that occur during the maneuver to provide a better understanding of the turning behavior. As a result, this research could be beneficial in comprehending the complete maneuverability of a container ship model in various shallow water port environments. It should be noted that the full version of this paper was published in Applied Ocean Research (Kim et al., 2022) by the same authors group. The results presented in the subsequent sections were adapted from the above-mentioned study.

3. METHODOLOGY

The methodology used in this study is outlined in this section, alongside a thorough explanation of the process in subsequent parts. The goal of the research is to investigate the maneuvering behaviors of the KCS in various shallow waters. The technique is comprised of four steps: 1) "goal and scope", 2) "numerical modeling", 3) "execution of free-running simulations", and 4) "results analysis". The process is depicted in a flow chart (Fig. 1) and is based on the methodology from the researchers' previous work (Kim et al., 2021a), adjusted to meet the objectives of this study. Step 1 defines the whole purpose and scale of the analysis. The second step outlines the numerical modeling aspect of the free-running CFD model. The third step involves conducting 'free-running' maneuvers using the Computational Fluid Dynamics model established in previous steps. The final step showcases and discusses the results obtained from the CFD simulations, with a focus on the connection between the vessel's turning operation and depths of the water.

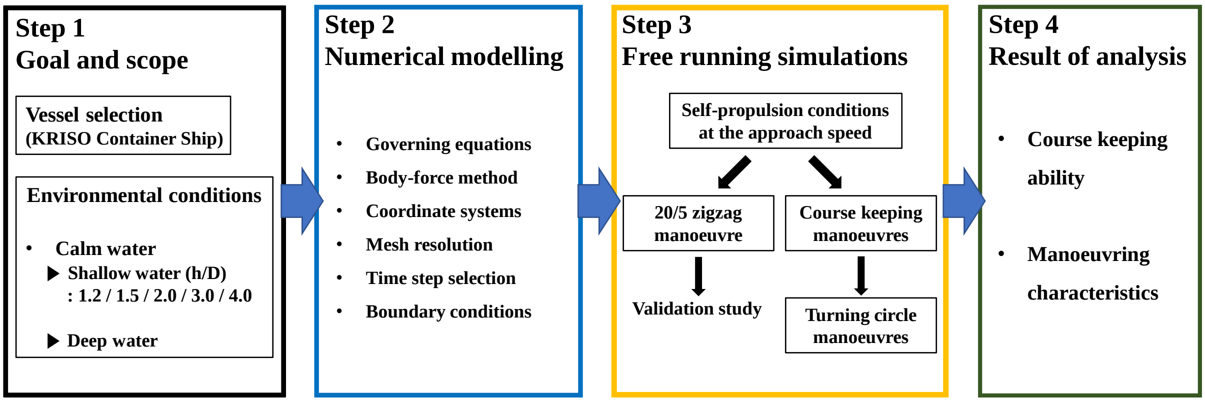

Figure 1: Suggested research procedure for the Computational Fluid Dynamics 'free-running' models

3.1 Step 1: "Goal and scope"

The objective of this work is to give a thorough knowledge of the impact of restricted water depth on ship maneuverability. This research will focus on:

1) Creating a numerical standard for 'free-running' maneuvers in restricted water
2) Validating the Computational Fluid Dynamic model using the results from the available tanks testing
3) Conducting numerical simulations and analyzing the effects of shallow water on ship maneuverability (such as "course keeping" and "turning" abilities)

4) Providing suggestions for future work, taking into account the limitations of the current research.

The study conducted numerical simulations for the containership model, which was created by KRISO and had a scale factor of 75.24. The model was equipped with a "semi-balanced rudder" and an "actuator disk". Table 1 provides the main features of the geometry. The work considered 7 different cases to be modelled in Computational Fluid Dynamics, as shown in Table 2 and Figure 3. The first case (Case 0) was a 20/5 modified zigzag maneuver in shallow water with a h/D ratio of 1.2, and the experimental results were used as a benchmark for validation. The following cases (Case 1-6) were two characteristic 'free-running' maneuvers ("course-keeping" and "standard turning") in different h/D ratios (1.2, 1.5, 2.0, 3.0, 4.0, and deep water). The first step concerned completing "self-propulsion" at the advancing speed and maintaining a constant revolution speed of the actuator disk. Then, the course-keeping maneuvers were started from the "self-propulsion" condition, using a rudder controller to control the 'rudder deflection' angle. Finally, the standard turning circle maneuvers were performed to assess the restricted water effects on the ship's turning behavior.

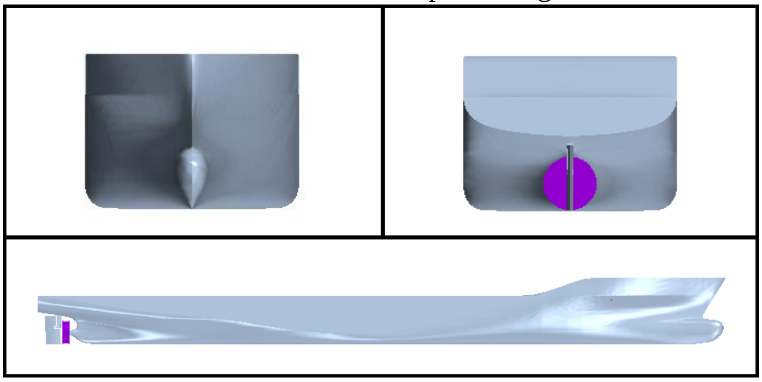

Figure 2: The containership model in question with a "semi balanced rudder" and an "actuator disk"

Table 1. The main dimensions of the containership model in question

Main particulars	Symbols	Model scale (1:75.24)
Length between the perpendiculars	$L_{BP}(m)$	3.057
Length of waterline	$L_{WL}(m)$	3.0901
Beam at waterline	$B_{WL}(m)$	0.4280
Draft	$\text{D}(m)$	0.1435
Displacement	$\Delta(m^3)$	0.1222
Block coefficient	C_B	0.651
Ship wetted area with rudder	$\text{S}\ (m^2)$	1.6834
Longitudinal centre of buoyancy	$\%L_{BP}$, fwd+	-1.48
The metacentric height	$\text{GM}(m)$	0.008
Radius of gyration	K_{xx}/B	0.49
Radius of gyration	$K_{yy}/L_{BP}, K_{zz}/L_{BP}$	0.25
Propeller diameter	$D_P(m)$	0.105
Propeller rotation direction (view from stern)		Right hand side
Rudder turn rate	(deg./s)	20.1
Froude number	Fr	0.095
Reynolds number	Re	1.25×10^6

Table 2. The simulation cases

Case	Surge speed U_0 (m/s)	Propeller rev. (RPS)	Depth/draft h/D	Free running simulations
0	0.518	6.75	1.20	20/5 zigzag, starting to port (**Validation case**)
1	0.518	6.75	1.20	Course keeping, 35° starboard turn
2	0.518	6.56	1.50	Course keeping, 35° starboard turn
3	0.518	6.43	2.00	Course keeping, 35° starboard turn
4	0.518	6.28	3.00	Course keeping, 35° starboard turn
5	0.518	6.24	4.00	Course keeping, 35° starboard turn
6	0.518	6.07	Deep water	Course keeping, 35° starboard turn

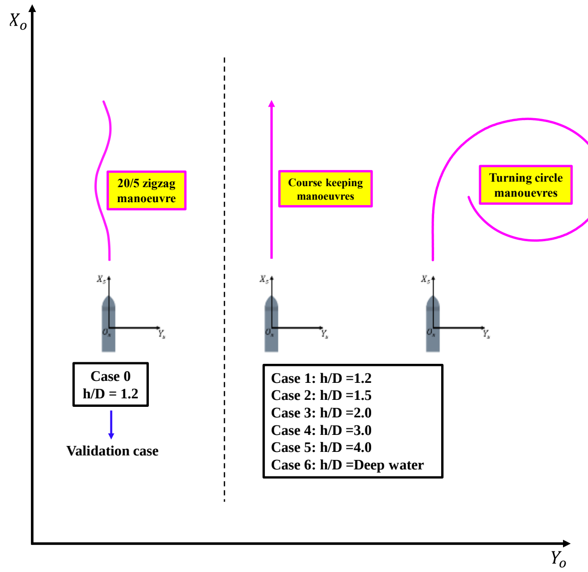

Figure 3: Graphic views of the simulation cases

3.2 Step 2: "Numerical modelling"

The study employed the industrial CFD package STAR-CCM+, "version 15.04", for numerical simulations (Siemens, 2020). The numerical approach used in the study is detailed in this section. The main features of the approach are described, including the turbulence models, grid generation, boundary conditions, and numerical solution method. The aim was to make sure an adequate level of precision for the Computational Fluid Dynamics simulations and to capture the complex hydrodynamic phenomena occurring during the free-running maneuvers in shallow water.

The ship propeller was modeled using a finite-thickness actuator disk by means of the "body force method", incorporating both 'axial' and 'tangential' forces in the flow field within the disc to mimic propellor behavior. The vessel used has a clockwise rotating, right-handed propeller, which propels the ship forward when seen from the aft of the ship. The simulations determined the direction of thrust produced by the disk model based on the characteristics of the right-handed propeller.

The computational domain was discretized using the Cartesian cut-cell method with the KCS model in STAR-CCM+. 6 separate grid generations were employed in the 'free-running' simulations, the precise number of which is listed in Table 3. The mesh density was refined in key areas such as around the hull body, between the rudder and horn, in the propeller wake region, and where the free surface was expected, to accurately capture complex flow features. A finer grid was specifically created between the ship hull and bottom boundary to properly resolve the hydrodynamic contact between the hull and seabed.

The CFD model's computational domain was divided into three regions: 1) background, 2) hull overset, and 3) rudder blade overset, as shown in Fig. 4. A dynamic "overlapping grid technique" was used for the last two regions to mimic the full 6 "degree-of-freedom" movements of the model and the rudder during the maneuvers. The dynamic overset approach allows independent handling of the movement of overset parts without restrictions. The gap spacing between the helm blade and root was marginally altered due to challenges in simulating the moving rudder in tight gap areas that may hinder valid interpolations between meshes.

Table 3. The overall mesh figures for the 'free-running' models

Case no.	Total cell number
0 (h/D=1.2)	8,8 million
1 (h/D=1.2)	8,8 million
2 (h/D=1.5)	8,9 million
3 (h/D=2.0)	9,5 million
4 (h/D=3.0)	9,9 million
5 (h/D=4.0)	10,2 million
6 (Deep water)	8,1 million

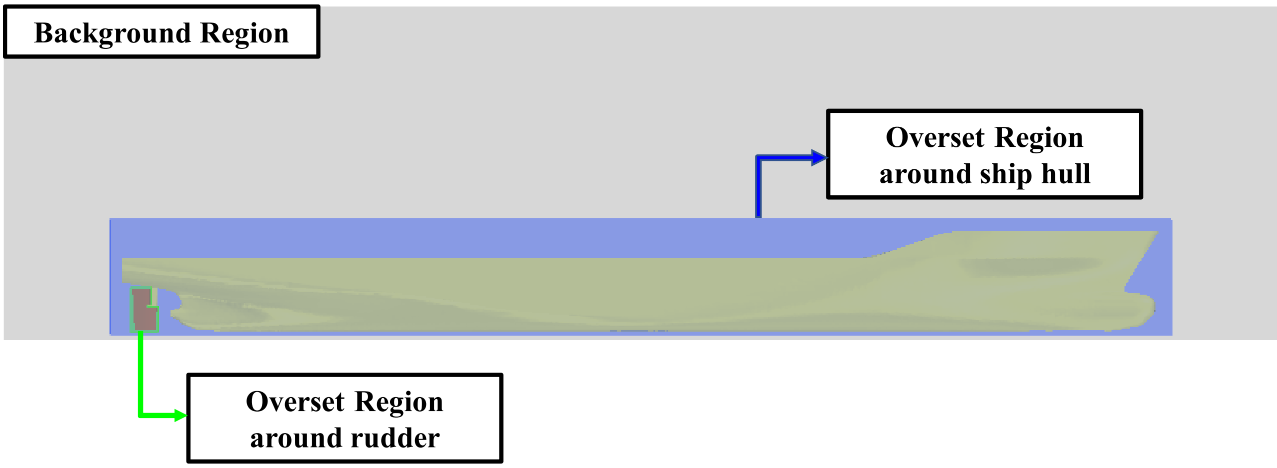

Figure 4: Illustration of the numerical domain for the 'free-running' CFD model

In this study, all free-running CFD simulations satisfied the Courant-Friedrichs-Lewy (CFL) condition by maintaining a CFL number less than 1 for numerical stability. The ITTC (2014) recommends using Δt≤0.01*Length/V for the time step (Δt) selection, with *V* being the ship speed. However, a more reliable level of accuracy for complex phenomena was achieved in this work by using a time step of Δt=5x10^{-3} seconds, which is ten times smaller than the recommended value. The use of Δt=5x10^{-3} seconds has been proven to be reasonable in calculating the maneuverability of a '1÷75.24' scale containership model in question (as used in this work) through URANS-based simulations (Kim et al., 2021a).

The shallow water simulations (Case 0-5) used velocity inlet boundary conditions at the upstream, side, and top boundaries to avoid velocity gradients, and a pressure outlet at the downstream boundary. The bottom boundary was set as a stationary no-slip wall to represent the sea floor. Moving bodies (hull and rudder) had no-slip wall conditions. To prevent wave reflection, wave damping with a length of 1.0 LBP was applied at the vertical boundaries. For 'deep-water' CFD model (Case 6), the only variation was the bottom boundary was set as a velocity inlet to represent deep water.

3.3 Step 3: Free running simulations

The 20/5 zigzag maneuver, the course keeping control, and the turning circle maneuver were performed for the KCS in this study. The control function for the modified 20/5 zigzag maneuver is as follows:

(1) $$\delta(t)=\begin{cases}\min(kt,20)\text{, 1st Rudder Execution } (t_1\le t\le t_2)\\ \max(20-k(t-t_2),-20)\text{, 2nd Rudder Execution } (t_2\le t\le t_3)\\ \min(-20+k(t-t_3),20)\text{, 3rd Rudder Execution } (t_3\le t\le t_4)\end{cases}$$

where *t* is the time passed after the beginning of each helm implementation, δ(t) is the helm angle, *k* is the maximum helm rate (k = 20.1º/s). The ship was traveling straight at full speed when the rudder was first moved 20º to the port (1st rudder execution). This caused the ship to turn towards the port. When the ship had veered 5º off course, the rudder was moved 20º to the starboard (2nd rudder execution). This made the ship turn towards the starboard, slowing down its port ward turning until it reversed direction. Finally, when the ship reached 5º towards the right-hand side, the helm was moved back to the left-hand side (3rd helm implementation).

A control module was designed to assess the ship's course-keeping ability:

(2) $\delta(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt}$

(3) $e(t) = \psi(t) - \psi_c$

where $\psi(t)$ is the sudden yaw position at a particular time, ψ_c is the target yaw position which was defined at zero degrees to hold the vessel in course. K_p, K_i, and K_d denote the relative, integral, and derivative "control gains", in that order. In this numerical set-up, the "control gains" were calculated by means of the "trial-and-error method" ($K_p = 5, K_i = 0.05, and\ K_d = 3$). It is worth mentioning that the turning circle maneuver uses highest helm deflection (thirty-five degrees) to the right-hand side at highest helm rate and keeps the capacity rudder angle steady till the maneuver ends.

4. RESULTS

In all cases listed in Table 2, the methodology's steps 1-3 were applied to the KCS model. Readers can refer to Kim et al. (2022) for validation and verification.

4.1 Course keeping control

Ships in waters usually go along with a steering path of straight-line routes (set by a captain as well as navigators) not including for evasive maneuvers or planned course changes. This highlights the importance of evaluating a ship's ability to maintain a straight course, making it crucial to assess course-keeping behavior under various sea conditions for safe navigation.

The results of the course-keeping simulations are displayed in Fig. 5, showing the ship's actual path compared to the target course. The deviations are small, indicating good "course-keeping" capability in the absence of outside factors for instance gusts, seas, and tides (Kim et al., 2021b). Table 4 summarizes the average quantities of "approach speed", drag, vertical ship movements at the maneuver. The ship's heading was kept close to 0°, with rudder deflection angles within 2.0º due to the asymmetric flow field caused by the propeller. The effect of water depth on resistance was shown to increase as the proportion of depth to draft decreases, together with the resistance in shallow water being 59% higher than in deep water. The ship experienced only minor heave and pitch motion due to its low approach speed.

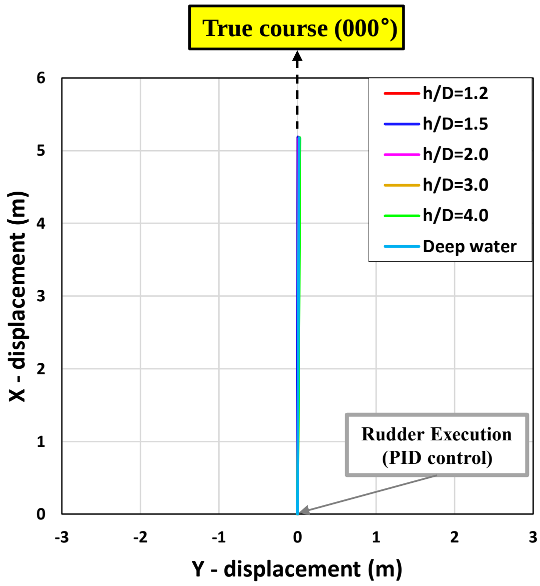

Figure 5: Evaluation of the paths practiced by the vessel in question at the "course keeping manoeuvre"

Table 4. The average quantities of the "approach speed", drag, vertical movements at the "course keeping" maneuver

Case no.	"Approach speed" U_0 (m/s)	Drag (Newton)	Heave (meters)	Pitch (deg)
1 ($h/D = 1.2$)	0.518	1.913	0.0033	0.165
2 ($h/D = 1.5$)	0.518	1.669	0.0024	0.166
3 ($h/D = 2.0$)	0.518	1.474	0.0017	0.169
4 ($h/D = 3.0$)	0.518	1.367	0.0011	0.172
5 ($h/D = 4.0$)	0.518	1.323	0.0008	0.172
6 (Deep water)	0.518	1.204	0.0004	0.171

4.2 Turning circle maneuver

Here in the current subsection, the turning capability of the self-propelled containership model in question will be evaluated in shallow waters, compared to its characteristic turning capability in calm, open water. The impact of restricted depths on maneuvering performance will also be analyzed. The standard turning circle maneuver involves the ship sailing forward under 'self-propulsion', then the helm being deflected to a hard-over angle of thirty-five degrees to the starboard side, at a maximum rate of twenty point one °/s. This causes the vessel to turn in the right-side path. The simulations end when the ship's heading angle reaches 360°, as per the procedure outlined by IMO (2002). The simulation time varies based on the ship's yaw velocity during the maneuver. The ship's turning behavior is assessed using standard factors such as 'advance', 'transfer', 'tactical diameter', and 'time' to '90°/180° heading' changes.

The turning circle maneuver's predicted ship trajectories are shown in Fig. 6, using the "earth-fixed coordinate system" with the origin point being the position where the rudder was applied. The results of the maneuver parameters are presented in Table 5 to quantify the ship's turning quality for every case. The effect of restricted depth on the ship's turning operation may be seen from the differences in the turning path. The vessel's turning capability was poorer in restricted waters in this paper at ports defined with different water depths (h/D=1.2, 1.5, 2.0) than in open water. In spite of the like velocity (Froude number is 0.095), the vessel had greater "tactical diameters" (Figure 6 and Table 5) due to inadequate "Under Keel Clearance" (the distance among the ship's lowest point and the seabed), causing powerful hydrodynamic contact with the seabed and altering the ship's turning performance. The lesser the "Under Keel Clearance", the larger the vessel's "turning diameter". However, the vessel's maneuvering in restricted waters with the ratio of water depth to the vessel depth three and four was identical to deep water, indicating that the restricted water effect on the vessel's maneuverability weakened when the above-mentioned ratio was larger than three.

According to Yeo et al. (2016), the impact of shallow water on a ship's turning performance was studied through "free-running" tank tests of the KVLCC2 in restricted waters (h/D=1.2, 1.5, and 2.0). The findings are given below:

(1) Turning maneuvers resulted in a slower change in the ship's heading angle in shallower water depths.
(2) The ship performing turning maneuvers experienced increasing hydrodynamic forces as the proportion of water depth to draught reduced exponentially.
(3) Smaller h/D ratios were found to result in increased turning parameters such as ship advance, transfer, and tactical diameter transfer, and tactical diameter.

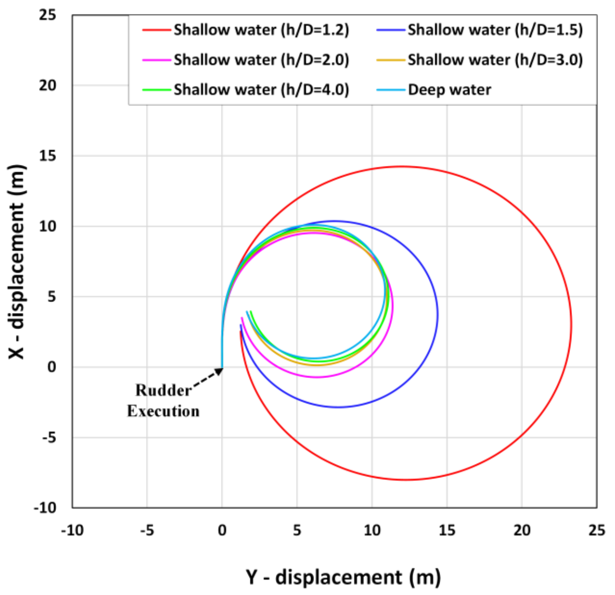

Figure 6: The simulated turning paths for each case

Table 5. Numerical outcomes for the turning factors

Parameters (CFD results)	Case 1 (h/D=1.2)	Case 2 (h/D=1.5)	Case 3 (h/D=2.0)	Case 4 (h/D=3.0)	Case 5 (h/D=4.0)	Case 6 (Deep)
Advance (m)	14.23 **(4.66L_{BP})**	10.33 **(3.38L_{BP})**	9.45 **(3.09L_{BP})**	9.57 **(3.13L_{BP})**	9.73 **(3.18L_{BP})**	9.89 **(3.24L_{BP})**
Transfer (m)	11.56 **(3.78L_{BP})**	6.82 **(2.23L_{BP})**	5.16 **(1.69L_{BP})**	4.80 **(1.57L_{BP})**	4.80 **(1.57L_{BP})**	4.65 **(1.52L_{BP})**
Time for yaw 90 degrees (s)	47.24	32.51	27.97	27.64	27.92	28.04
Tactical diameter (m)	23.28 **(7.62L_{BP})**	14.34 **(4.69L_{BP})**	11.29 **(3.69L_{BP})**	10.85 **(3.55L_{BP})**	10.94 **(3.58L_{BP})**	10.67 **(3.49L_{BP})**
Time for yaw 180 degrees (s)	93.88	64.51	55.38	54.49	54.78	55.21

5. CONCLUSIONS

This study showed the effectiveness of using a direct CFD model, with an unsteady Reynolds Averaged Navier-Stokes solver, to estimate the maneuvering operation of a benchmarking model at ports which were defined using various water depths. Key findings:

(1) The maneuvering vessel at ports (i.e., in restricted waters) exhibited reasonably well "course-keeping control", as shown by its real sailing courses being steady with the real course. This

indicates that the restricted depths have little impact on "course keeping" when there are no outside disturbances such as waves.

(2) The study emphasized the impact of restricted depth on the ship's turning behavior by comparing the so-called "critical turning" factors and hydrodynamic properties with h/D ratios. Decreasing h/D led to increased "ship advance", "transfer", and "tactical diameter". For h/D = 1.2, the predicted transfer and tactical diameter were more than double those for open water, for the identical "approach speed" (Froude number is 0.095). No significant difference was found in the "turning parameters" between h/D= 3.0, 4.0, and open water, indicating negligible impact on the ship's maneuvering performance in these particular depths.

(3) Deeper depths resulted in larger "involuntary speed loss" during the transitory stage of the turn due to increased drag with heightened drift angle. "Speed loss rate (between initial surge velocity and minimum value) was 57% for h/D = 1.2, 64% for h/D = 1.5, 68% for h/D = 2.0, 70% for h/D = 3.0, 71% for h/D = 4.0, and 72% for deep water" (Kim et al., 2022).

(4) The stream area faced by the maneuvering vessel was analyzed, revealing complex connections between the "hull wake", "boundary layer", "propeller", "vortex", and sea bottom (Kim et al., 2022).

6. ACKNOWLEDGMENTS

"It should be noted that the results were obtained using the ARCHIE-WeSt High-Performance Computer (www.archie-west.ac.uk) based at the University of Strathclyde". The full version of this paper was published in Applied Ocean Research (Kim et al., 2022) where the results presented in this paper were taken from.

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REVIEW ON SHIP RECYCLING INDUSTRY

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ABSTRACT

Ship dismantling for recycling, also known as ship scrapping, is a crucial component of the maritime industry. This expanding industry has a significant impact because it uses the large steel ships when they are no longer needed. The owners, shipyards, and recycling industry will all profit from this use. Several studies have looked into and addressed a few aspects and subcategories of this dynamic market. However, none of them has conducted a thorough review of the academic research studies on ship recycling that are currently available. Therefore, the purpose of this review is to provide a brief overview of the development of scholarly inquiry into the emerging subject of ship recycling. To that end, we conducted a systematic literature review of ship recycling topic on a sample of 100 papers related to that field. the objectives of that review are to identify the topics of academic research in that field, the employed methodologies, the main research challenges and directions in connection to ship scrapping. To achieve these objectives, we designed a methodology flow chart to be our frame work and throughout its steps we revealed some facts and conclusions based on 51 screened papers. The results demonstrated that Top leading countries in ship recycling industry are Pakistan, India, Bangladesh, China and Turkey. The results also demonstrated that the main research focus is concentrated on HSE impacts & challenges, operations and management. there is a lack of studies in areas related to design considerations, economic and legal issues. Moreover, almost no scientific research has been published in regarding with this industry implementation in Egypt. Based on the analyzed literature, the policy makers can make use of this information about research collaborations, groups, and directions to determine opportunities for investing and implementing ship recycling techniques that comply with standards in an efficient manner for environment, economy and safety insurance, moreover research investments could be influenced by this information in a way that make touchable advancements to that growing industry.

Keywords: ship recycling, ship scrapping, systematic literature review, environmental impacts, design for recycling, material flow analysis, Hong Kong Convention, EU regulations.

1. INTRODUCTION

Ship breaking, dismantling, scraping, demolition and ship disposal are expressions with a same meaning which ends at ship recycling yards. The ship recycling industry is a vigorous market which offers a huge profit to the ship owner, ship brokers and the cash buyers from selling ships as scrap. At the end of this loop between ship owner, ship broker and the cash buyer, the ship recycling yard buys the ship according to its light weight or light ship displacement from the cash buyer. Most of the ship owners prefer to sell their ships to the cash buyers directly because they pay the price of the ship as lumpsum to the ship owner and gain his commission. Moreover, the cash buyer associates the ship owner with the ship recycling yard, so he plays an important role between them to complete the deal between them.

The ship recycling industry starts after the second world war and it is situated in the industrial countries like Germany, Italy, United Kingdom, United States and Scandinavian countries till 1980. Recently, the ship recycling industry is transferred to another five countries which are India, Bangladesh, China, Pakistan, and Turkey.

The IMO has acknowledged that recycling ships is the best way to get rid of obsolete ships because it is seen to help to the economic and sustainable growth of society by releasing the Hong Kong Convention and the European Union recycling regulations (IMO, 2009). Additionally, the IMO's acceptance means that the ship recycling industry will create hundreds of thousands of jobs for skilled, semi-skilled, and unskilled workers in developing nations like Bangladesh, China, India, and Pakistan. Ship recycling also recovers millions of tons of scrap for recycling in steel factories.

In the ship recycling sector, there is a difference between yards that adhere to international regulations and safety standards, such as the Hong Kong Convention and the European Union Recycling Regulation, and non-compliant or subpar yards that charge more than the standard ship recycling yards. The high expense of enforcing health, safety, and environmental regulations, as well as worker exploitation in recycling yards and the requirements for worker welfare in conventional ship recycling yards, all contribute to this condition. As a result, the owner of the ship will not consider selling it to the typical ship recycling yards because of the price difference. In a nutshell, to fill this gap, the total cost of ship recycling process must be less than the revenue for the ship recycling yard so the yard will gain.

2. Methodology

Systematic Literature Review Method has been conducted on a data set of 100 papers related to ship recycling topics to reveal the leading countries working in ship recycling industry, also Main research categories and aspects have been determined. This facilitate revealing uncovered Research areas and knowledge gaps which recommend future work for scholars working in that field. Systematic Literature Review is a qualitative analysis that summarize and synthesize the findings of reviewing existing literature. It has been chosen because our data set is about 100 papers that can be processed manually through. Moreover, the scope of review is very specific. Figure (1) shows A Flow chart clarifying all the steps of our methodology.

2. ship recycling aspects

The following section provides a brief discussion of the electively selected research activities of open literature through the last 12 years. It is divided into 6 parts; Design considerations in ship recycling industry, Environmental impacts of ship recycling, Health safety and environment challenges, Economic aspects related to ship scrapping, Legal issues for ship breaking and Operations and asset management in ship demolition. The statement will always start with the problem definition for each paper, then methodology utilized and ended with the findings.

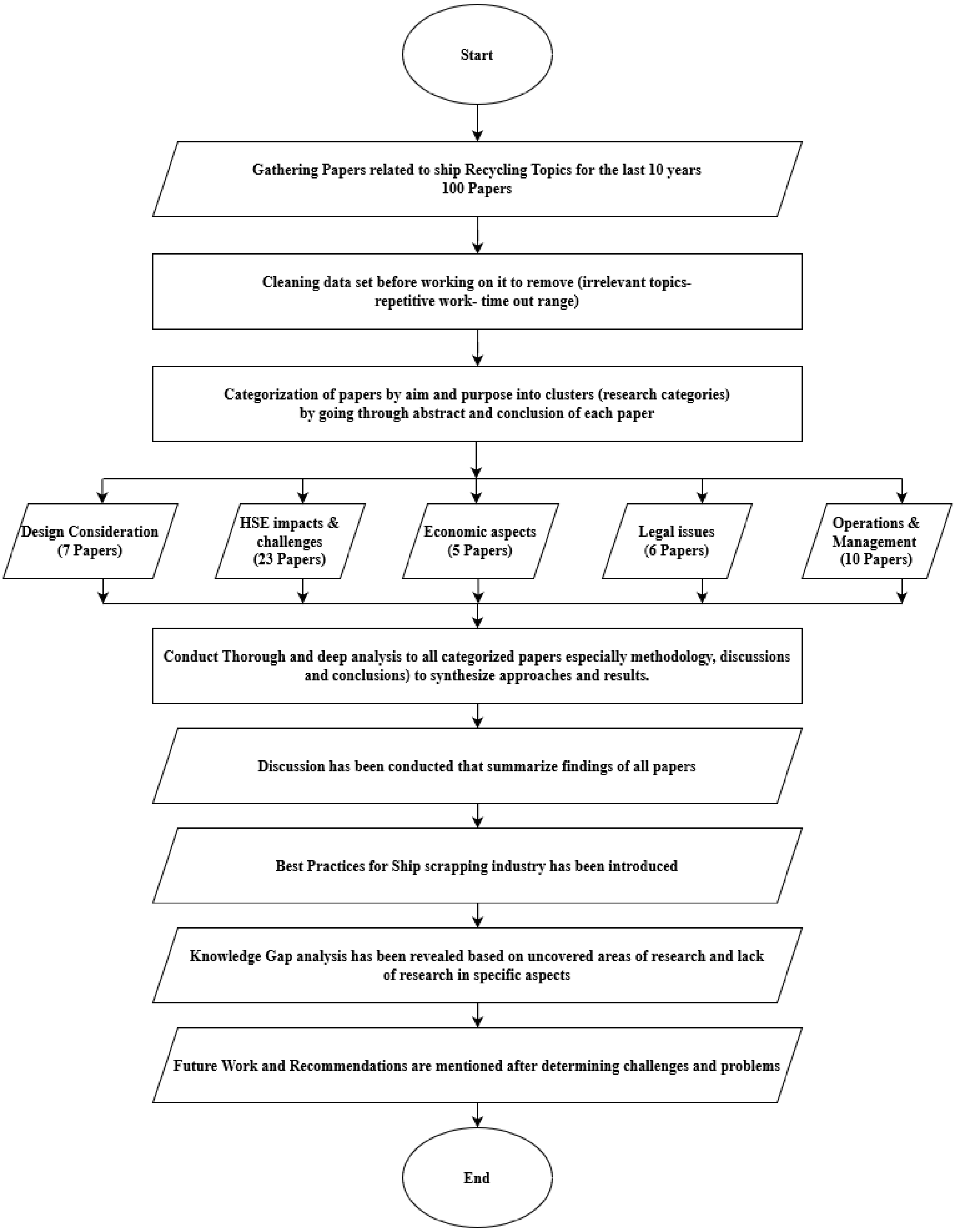

Fig 1. Methodology Flow chart

2.1 Design consideration.

Design is one the most important factor among other factors affecting the ship breaking industry success, the following paragraphs discusses the research effort from 2013 to 2020 including seven research papers. The design stated below includes ship design for future recycling, green ship recycling yard layout design and the design of ship recycling plan.

K. Sivaprasad et al. (2013) [1], K.P. Jain et al. (2015) [2] and K.P. Jain et al. (2016) [3] investigated the lack implementation of ship recycling industry in the basic principles of ship design. While S. Sunaryo et al. (2015) [4], p. Fariya et al. (2016) [5], S.A. Gunbeyaz et al. (2018) [6] and Sunaryo et al. (2020) [7] focused on the gap between green ship recycling yards and non-green ship recycling yards.

K. Sivaprasad et al. (2013) [1] conducted a recyclability analysis of ships presented as part of the implementation of the maritime industry's sustainable development philosophy. Furthermore, K.P. Jain et al. (2015) [2] conducted a scientific analysis of the ship recycling process and identified design and construction solutions that need to be considered to achieve safe and environmentally sound ship recycling. For the layout of a green ship recycling yard for Indonesian merchant ships, Sunaryo et al. (2015) [4] Conducted a design study. Additionally, K.P. Jaina et al. (2016) [3], for a vessel life cycle analysis he performed three reverse steps. Furthermore, S.A. Gunbeyaz et al. (2018) [6] performed an optimization study for each step of ship recycling by introducing a simulation model using ARENA software. Furthermore, S. Fariya et al. (2016) [5] performed a data processing study using the Analytical Hierarchy Process (AHP). Finally, a design review of the layout of the Green Ship Recycling Yard for general cargo and tugs and barges by Sunaryo et al. (2020). [7]
K. Sivaprasad et al. (2013) [1] advocated After considering the critical role in achieving clean and safe end-of-life ship dismantling, a new ship life model was created by adding several stages to the traditional life cycle. All of Sunaryo et al. (2015) [4], S. Fariya et al. (2016) [5] and Sunaryo et al. (2020) [7] Developing a simulation model for the layout of a green ship recycling yard, K.P. Jain et al. (2015) [2] developed a methodology to build a scientific model for optimizing ship recycling yards for cost-effective green ship recycling as shown in figure 2. Additionally, K.P. Jain et al. (2016) [3] proposed a new format for easy distribution to store such critical information for ship recyclers. Finally, in order to improve and optimize the ship recycling process, framework has been developed for the ship recycling sector using the S.A. Gunbeyaz et al. (2018) [6] ARENA simulation model.

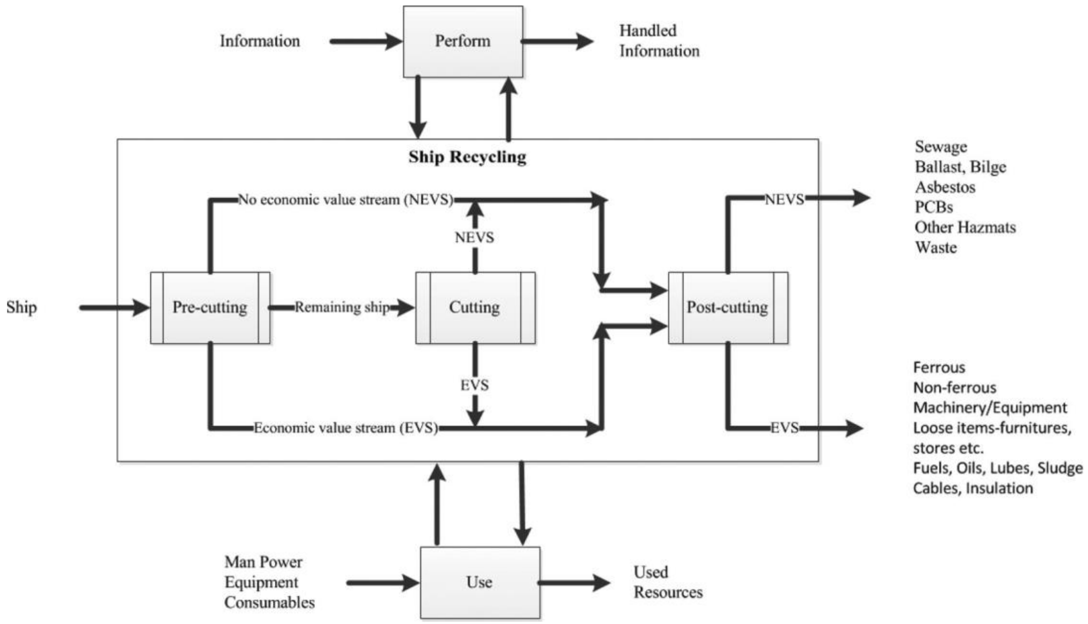

Fig.2 ship recycling process.

2.2 HSE Impacts & Challenges

The pollution which occurs due to substandard ship recycling process leads to harmful environmental impacts. The following research papers ranging from 2012 to 2021 includes 13 papers discussing different issues related to environmental impact problems.

S.M. Yahya et al. (2012) [8] investigated the environmental impacts of the shipbreaking and recycling industry in Bangladesh. As a result of unethical shipbreaking in South Asia, Yousri MA Welaya et al. (2012) [9] investigated the feasibility of building a ship recycling yard in Egypt. This is done to draw attention to worker health, safety and harm to the environment. Furthermore, Asma Binta Hasan et.al. (2013) [10] Potential enrichment of trace metals in the sea and groundwater from shipwreck activity along the Bay of Bengal in Sitakund and Upazila, Chittagong, Bangladesh. Asma Binta Hasan et al. (2013) [11] investigated that trace metal concentrations were higher around the shipbreaking area of Sitakund Upazilla in Chittagong, Bangladesh, than at control sites. Furthermore, Nathanel Ko et.al (2016) [12] introduced that there is a certain imbalance between the added value of scrapped ships and the distribution of environmental impacts over the life of the ship. In addition, Sohanur Rahman (2017) [13] discussed the current status of ship recycling in Bangladesh to overcome the negative impacts on environment and human life. In addition, Hasan Luhan Rabia et al. (2017) [14] Focused on Bangladesh's Ship Recycling and Recycling Industry (SBRI) to understand its current status, environmental impact, and workers' rights and safety. Learn about the Bangladesh Ship Breaking Association (BSBA) response to dirty and dangerous shipbreaking facilities. Furthermore, Damien A. Devault et.al (2017) [15] stated that management of decommissioned vessels is a serious problem as most Ship Recycling Facilities (SRF) are located in developing countries. As a result of a study by Zunfeng Dua et al. (2018) [16] uncontrolled disposal of hazardous materials such as asbestos and waste oil can have serious negative impacts on the environment and human health. Furthermore, Kanu Priya Jain et al. (2018) [17] showed that it is costly to apply waste management and recycling processes in 'environmentally friendly' ship recycling yards. Furthermore, Yucel Ozturkoglu et.al. (2019) [18] On the dynamic environment of ship recycling and the various significant risks that can result. In addition, significant hazardous waste from ship recycling was reported by Md. Jahir Rizvi et al. (2020). [19] The "beaching method" is particularly important because of its mode of operation. Finally, Qingji Zhou et.al (2021) [20] studied factors influencing green ship recycling to avoid pollutants in shipbreaking.

S.M. Yahya et al. (2012) [8] performed the following set of tasks: visits to scrap processing and refinery facilities, onshore and offshore sample collection and analysis of experimental data, on-site evaluations and interviews with stakeholders, including workers, shipyard managers and other stakeholders; and preparation of an EIA report from interviews with relevant stakeholders. Further, Yousri MA Welaya et al (2012) [9] A Fuzzy Logic Approach is Used to Assessment the Benefits of the Ship Breaking Yard through MATLAB ver. 7.6.0 with Fuzzy Logic Toolbox. Additionally, Asma Binta Hasan et.al (2013) [10] conducted a comparative study for seven seawater and seven ground water samples were collected from the ship breaking area of Sitakund Upazilla Chittagong, Bangladesh in February 2011 in order to trace element concentrations of seawater samples with the average abundance of elements in the Earth's seawater standard. Besides, Asma Binta Hasan et.al (2013) [11] carried out Sediment geochemistry analysis and conducted a correlation between trace elements of sediment samples Correlation matrix in order to indicate enrichment factor, the geo-accumulation index and the potential contamination index. Moreover, Nathanael Ko et.al (2016) [12] carried out by Life Cycle Assessment (LCA), for the quantification of the environmental impacts, local added value, for the quantification of economic impact and the method of eco-efficiency. On the one hand, Sohanur Rahman (2017) [13] carried out a comparative study for the overall ship recycling process in Bangladesh compared with the Rest of World on ship recycling activities through gathering data from different sources (references) focusing on ship recycling in Bangladesh. On the other hand, Hasan Ruhan Rabbia et.al (2017) [14] carried out an analytical study for the general overview of Ship Breaking and Recycling Industry (SBRI), the impact of environmental disaster, the problems involved in workers safety in order to find out the solutions of the challenges occurred in SBRI. In addition, Damien A. Devault et al. (2017) [15] conducted a comparative study of shipbreaking and sinking based on a review of environmental, economic and forensic aspects. Also, Zunfeng Dua et.al (2018) [16] On-site observations and investigations were conducted to consider disposal methods for hazardous materials. The survey was conducted at several ship recycling companies of various sizes, including the Yangtze River Shipbreaking Yard, Zhoushan Changhong International Ship Recycling Co., Ltd., and Tianma Ship Recycling Yard. In addition, interviews and surveys were conducted with managers of these ship recycling companies or people familiar with the process. Additionally, Kanu Priya Jain et.al (2018) [17] A financial analysis performed to quantify the waste generated in a ship recycling yard with an annual scrapping capacity of 1 million tons. Additionally, capital costs, operating costs, and revenues were determined to quantify changes in offer prices. Furthermore, Yucel Ozturkoglu et al. (2019) [18] Fuzzy DEMATEL method for analyzing causal relationships between economic and environmental risks. Furthermore, Md Jahir Rizvi et.al. (2020) [19] presented an alternative approach to current shipbreaking operations by creating a computer model of a portion of a shipbreaking site and analyzing it using a commercial software package from Multiphysics. Finally, the Qingji Zhou et.al (2021) [20] questionnaire was designed and conducted by scientists, managers, and workers in the ship recycling field. The data were analyzed based on structural equation modeling SEM using the proposed theoretical model.

All S.M. Yahya et al. (2012) [8], Asma Binta Hasan et al. (2013) [9] and Asma Binta Hasan et al. (2013) [10] found that ship debris was randomly staked to shore, leaving an accumulation of rusty metal debris on the ground. Furthermore, this analysis revealed that the sediments in the shipbreaking area were either slightly or heavily contaminated with the investigated trace metals according to the Igeo values. Furthermore, Yousri MA Welaya et al. (2012) [11] found that poor practices in the current disposal regime cause significant health, safety and environmental harm. Also, the fuzzy logic approach used to assess the benefits of the shipbreaking industry has proven to be suitable for decision making. Furthermore, the results of the research conducted show that the location of the ship recycling facility has no impact on labor and transportation costs. However, this will affect infrastructure costs. Also, Nathanel Ko et.al (2016) [12] found that the environmental impact per value added (inversely adjusted eco-efficiency) is higher at the production stage, especially at the disposal stage. Economic benefits also accrue during the use phase and remain in Europe reflecting the ship's purpose. Since ships are in use for a long time, most of the environmental pollution also occurs during the use phase, but it is emitted all over the world. As well as Sohanur Rahman (2017) [13] and Hasan Ruhan Rabbia et.al (2017) [14] state that there are no separate guidelines or regulations for shipbreaking in Bangladesh. Additionally, recycling shipyards do not employ shipbuilders and almost all ship dismantling is done with minimal guidance from engineers. Additionally, a Ship Recycling Plan as defined in accordance with Resolution MEPC196(62) must be drafted and submitted to the Authority for approval prior to recycling. During the recycling process, inspectors must check whether the recycling yard follows this process. However, Qingji Zhou et.al (2021) [20] showed that organizational and management factors have the greatest overall impact on environmentally friendly ship recycling. Environmental protection facilities and planning factors are followed by ship recycling technology and equipment factors. Additionally, Damien A. Devault et.al (2017) [15] found that while scrap provides employment and raw materials, it carries environmental, health and safety costs. Scuttling, on the other hand, offers opportunities for fishing and diving tourism, but requires proper management to avoid organic matter. and metal contamination. Plus, flag of convenience is inevitable tool for converting obsolete ships. 61% of the world's merchant fleet has such flags. Both Zunfeng Dua et.al (2018) [16] and Md Jahir Rizvi et.al (2020) [19] found that shipbreaking is widely associated with unsafe practices and pollution, PCB, glass fiber, rigid foam, waste oil, etc. Also, currently the ship design process "Design for Recycling" does not consider the recycling process. Similar to Kanu Priya Jain et.al (2018) [17], the results suggest that the return on investment for plasma gasification plants is relatively fast, with a reasonable increase in asking price under the specific scenario considered in this study. showed that it is possible. Finally, Yucel Ozturkoglu et.al (2019) [18] The first contribution of this study is to combine the TBL approach with risk management in the ship recycling industry. The second contribution analyzes the interrelationships between factors and proposes risk area proposals that recommend management implications for sustainable risk management in the ship recycling industry. Finally, the implementation of Green Supply chain management is proposed.

The non-green ship breaking process exposes the ship breaking workers to a serious risk on health and safety. Throughout the next paragraph, 10 research papers covering years from 2012 to 2021 discusses problems in health safety and environment.

Safety, health, and environmental concerns were addressed by N.M. Golam Zakaria et al. (2012) [21] It has been highlighted as a major factor in the challenges facing the ship recycling industry. It also briefly outlined the strengths, weaknesses, opportunities and threats of the industry from a global perspective. Furthermore, Paritosh C. Deshpande et al. (2012) [22] discussed pollutants emitted from plate cuttings at Alang, India. Pollutants either directly affect workers by polluting breathing zones (air pollution) or pollute intertidal zones and contaminate sediments when pollutants are released in secondary work zones receiving tidal forces. Furthermore, Paritosh C. Deshpande et al. (2013) [23] Also, a thorough understanding of the inputs and outputs of plate cutting operations at Alang, India, is essential to anticipate and control the health, safety, and environmental risks associated with ship recycling. Furthermore, Widha Kusumaningdyaha et.al. (2013) [24] point out that shipbreaking contributes to toxicants leading to ecological imbalances in exposed areas. Shipbreaking is also a dangerous occupation with the risk of poisoning from hazardous materials and accidents on the premises. Additionally, Karin Garmer et.al (2015) [25] showed that environmentally friendly and safe disposal of old ships is a major challenge today. He studied three-step risk assessment methodology to reduce risk and increase safety in ship recycling yards. Further, a study by Halvor Shyen et al. (2017) [26] describes the difficulties faced by ship owners, recycling facilities and governments in trying to recycle old ships in an environmentally sound manner. Shipbreaking puts the environment and recycling plant workers at risk. Furthermore, Rafet Emek Kurt et.al. (2017) [27] analyzed hazardous noise exposure in a ship recycling yard by identifying noise sources and quantifying potential impacts on workers. In addition, Sefer A. Gunbeyaz et.al (2019) [28] highlighted numerous accidents and fatalities in the ship recycling process due to lack of proper occupational health and safety (OHS) standards. Zheng Wan et al. (2021) [29] introduced that ship scrapping is a significant source of marine pollution during ship recycling. This includes toxic chemicals that can be released and pose great danger to both the environment and public health. Finally, Qingji Zhou et.al (2021) [30] found that for vessels that have reached the end of their economic life, considering hazardous materials and work processes, sending these vessels for recycling is a sustainable option. Therefore, it is important for ship recyclers to ensure the safety of their workers.

Research and field visits by N. M. Golam Zakaria et al. (2012) [21] were carried out at several well-known local shipyards. In addition, professional participation was conducted through questionnaires and interviews. Consultations and meetings were held with government agencies, shipbreaking associations and stakeholders to understand the current challenges and future vision. Furthermore, Paritosh C. Deshpande et al. (2012) [22] performed a mathematical model of estimation using a Gaussian air pollution model to quantify pollutant concentrations along the centerline of each cutter designed as a single point source. Furthermore, Paritosh C. Deshpande et al. (2013) [23] conducted a theoretical study to investigate the relationship between emission rate and resource consumption in the cutting process in ship recycling, based on field observations in Alang, India. Furthermore, Widha Kusumaningdyaha et al. (2013) [24] system dynamics approach Performed using Ventana simulation software (Vensim). The model was developed in three steps. The first step is to develop a system structure that characterizes its behavior. This is illustrated by creating a causal loop diagram. In the second step, a Flock Stow diagram is created and extended to show the nature of the dynamic behavior of the structure. In the final step the model structure is simulated and evaluated. In addition, Karin Garmer et.al (2015) [25] 3-step risk assessment was conducted at 35 ship recycling yards through questionnaire surveys and door-to-door visits. A data set of 8 risk indicators (4 risk indicators each before and after corrective action is implemented). Additionally, nine of her datasets were collected to document expert perceptions. A total of 44 datasets were collected and used to validate the risk assessment method. A risk matrix was also created. Also, Halvor Schøyenet.al (2017) [26], based on data gathered from a literature review, relevant document analysis, and semi-structured interviews with selected Norwegian industry participants, analyzed literature reviews, companies, websites and NGOs, documents, interviews. Additionally, a noise exposure study was conducted at an operational ship recycling yard by Rafet Emek Kurt et.al (2017). [27] This included a general noise survey, individual worker noise exposure measurements, and comparison of results to exposure limits. Measurements specified in the European Union Physical Effects (Noise) (EC 2003b) are defined. Furthermore, Sefer A. Gunbeyaz et.al. (2019) [28] organized a field survey involving several ship recycling yards, several government agencies, universities, and BSBA training center. A comprehensive data collection survey was then conducted, covering Bangladesh and international health and safety training and international practices, worker evaluation, shipyard training records and training content, and BSBA training materials. As a next step, IMO and ILO requirements for worker training were communicated to the Expert Group, who was asked to assess BSBA training. Finally, training evaluations have been condicted based on the documentation and what was reported, rather than looking at the actual implementation of the training. Furthermore, Zheng Wan et al. (2021) [29] In his research study of 22,500 scrap ship business records from 2000 to 2019, using factors suggested to scientists, managers, and workers in the ship recycling industry. Additionally, the conceptual model and research hypothesis, On the other hand, theoretical model has been conducted hypothesizing based on the structural equation model using survey data, and performed model suitability evaluation and SEM analysis.

N. M. Golam Zakaria et.al (2012) [21] found that ship breaking is an important activity in the economy of Bangladesh as it contributes significantly to the conservation of energy and resources in general. Furthermore, Bangladesh has no choice but to improve safety, health and the environment through extensive infrastructure and capacity development, and this must be based on the results of research work. Although Paritosh C. Deshpande et.al (2012) [22] found that 180 ship recycling yards located at Alang-Sosiya beach in the state of Gujarat on the west coast of India constitute the largest cluster in the world engaged in scrapping operations. In addition, each year, 350 ships are dismantled (an average of 10,000 tons of steel/vessel) with the participation of about 60,000 workers. It was recognized from the outset of this study that the potential environmental impacts and occupational hazards were comparable regardless of the method of dismantling (i.e., in any decommissioning or repair site layout), as well as the degree of mechanization and manual labor in the yard. In addition, Paritosh C. Deshpande et.al (2013) [23] found that sheet cutting accounts for almost 70% of the total labor employed in ship dismantling and recycling at Alang-Sosiya shipyards in India. In addition, analysis of the contributions revealed that 6.2 kg of fuel was consumed per km of shear plate per mm of plate thickness, the volume of paint released to the ambient air and the paint deposited on the intertidal sediments. are 0.9 and 1.34 kg per km of sheet cut per mm of sheet thickness, CO_2 emissions are estimated to be 21.77 kg per km of sheet length per mm of sheet thickness, time spent in cutting action actual plate is 240 +- 27 minutes Burning time/(km of cutting length) (mm cutting depth) as shown in figure 3, and oxygen consumption per day is 28.5 +- 3.2 kg of oxygen/(km of cutting length) (mm depth of cut) as shown in figure 4. On the one hand, Widha Kusumaningdyaha et.al (2013) [24] The results can be considered in terms of regulation and policy implementation related to ship breaking and its aspects, especially in developing countries. On the other hand, Karin Garmer et al (2015) [25] found that there was no significant difference between the observed mean risk index based on field data and the indicated risk index, with no significant difference. There is a significant difference between expert risk perception and field personnel risk perception.

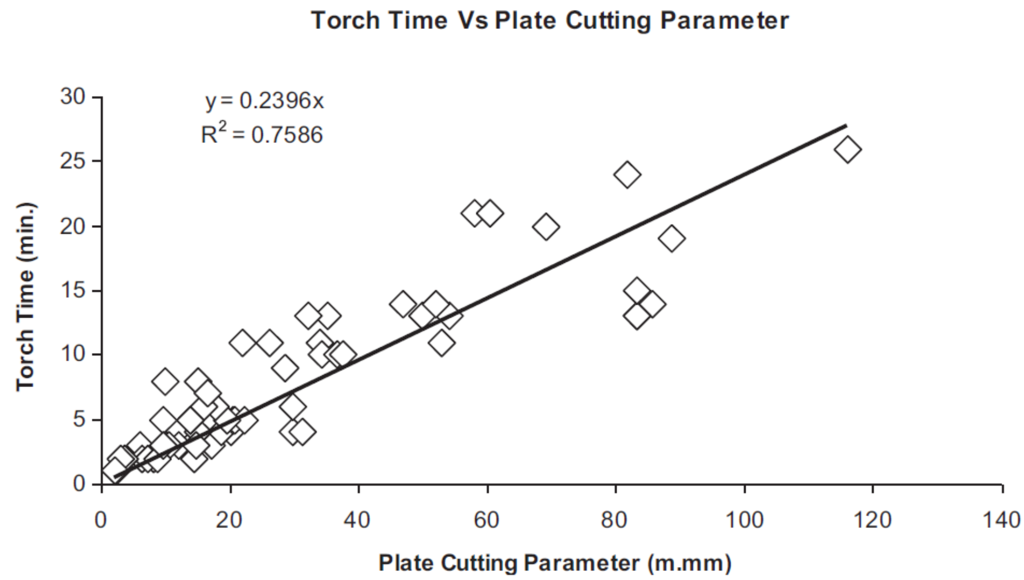

Fig. 3. Linear regression of Torch Time vs Plate Cutting Parameter. The slope (with 95% confidence interval), defined as Torch Time Factor, is 240 +- 27 min Torch Time/ (km cut length) (mm cut depth) and may be used to estimate the total Torch Time required for plate cutting for the entire ship.

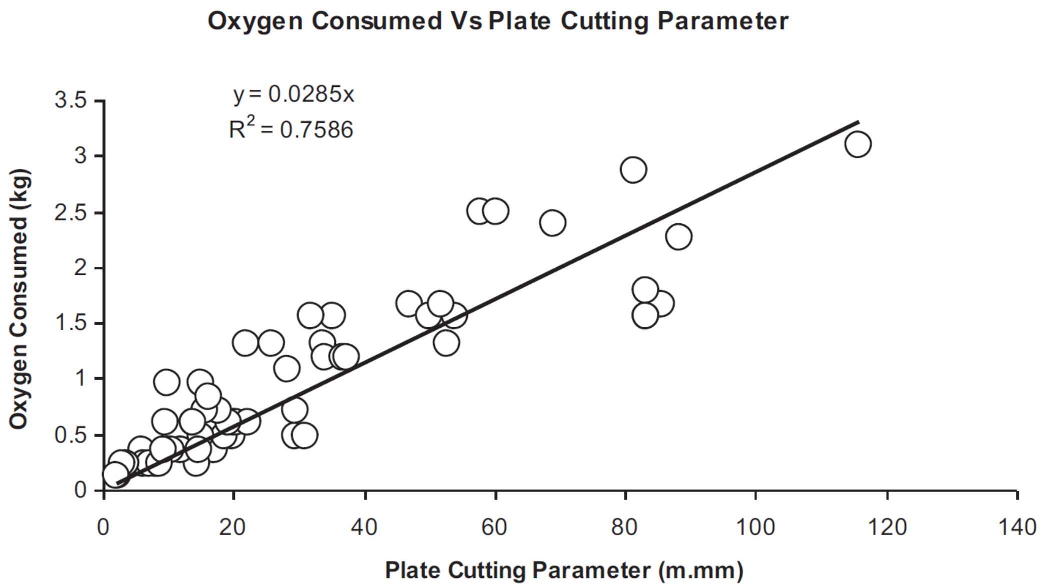

Fig. 4. Linear regression of Oxygen Consumed vs Plate Cutting Parameter. The slope (with 95% confidence interval), defined as Oxygen Consumption Factor, is 28.5 +- 3.2 kg Oxygen/(km cut length) (mm cut depth) and may be used to estimate the total oxygen consumed in plate cutting for the entire ship.

Halvor Schøyen et.al (2017) [26] and Sefer A. Gunbeyaz et.al (2019) [28] find that standardization is only possible through increased investment, i.e. in worker training, welfare, equipment and infrastructure. Furthermore, since ship breaking is not regulated internationally and shipowners frequently abandon their ships, much of the liability for environmental and safety issues at the shipyard rests with the shipyard. government. Moreover, Rafet Emek Kurt et al (2017) [27] the main finding of this study is that noise is a significant risk factor in ship recycling operations and that workers' hearing loss and injury is potentially serious. important for those who do not wear it or wear it incorrectly. hearing protection. Besides, Zheng Wan et.al (2021) [29] found that the phenomenon of "pollute first, clean up later" in developing countries is common. Thus, pollution control must be associated with international organizations setting higher standards and requirements. In addition, the improvement of the antifouling coating, used to kill algae and mollusks on the hull without the use of harmful chemicals, will reduce the impact on the marine ecosystem, increase the life of the ship by reducing corrosion, thereby significantly reducing the amount of waste generated.

Finally, Qingji Zhou et.al (2021) [30] hazardous materials and potential risks during ship dismantling process, the factors affecting workers' safety during ship recycling are proposed, including disposal of hazardous materials (DHM), dismantling operation safety (DOS), dismantling operation management (DOM), dismantling operation equipment (DOE), and safety awareness (SAW). Also, this study proposed and evaluated the factors affecting personal safety during ship dismantling which can enhance the existing literature on human safety analysis in ship recycling industry. Reliable findings were obtained based on inferential statistical methods.

2.3 Economic aspects.

The economic gains resulting from the scrapping of ships randomly, most of ship owners who want to scrape end of life ships leave the green ship recycling yards towards the non-green ones. The following research papers published from 2016 to 2020 includes 5 papers that introduce different drawbacks from an economic point of view.

Jun-Ki Choi et al. (2016) [31] examined the impact of substandard recycling practices in South Asian countries, allowing shipyard owners to outbid standard engineering recyclers and maintain profits as a result. lax environmental law enforcement. These non-standard technologies have the potential to release significant amounts of hazardous substances due to non-compliance with environmental standards. In addition, Zunfeng Dua et.al (2017) [32] studied the challenges faced by Chinese ship recycling companies as the ship recycling market suffered a downturn and stiff price competition from South Asian countries. Furthermore, Kanu Priya Jain et.al (2018) [33] explains that the implementation of international ship recycling regulations leads to increased costs for the ship recycling process, which is detrimental to the provision of high prices for ships. ship owner when buying a ship that has reached the end of its life. In addition, E. S. Ocampo et al (2019) [34] examines the legal, technical and economic aspects of ship recycling for Brazilian shipyards to do it in a sustainable way. Finally, Sunaryo et.al (2020) [35] conducted a feasibility study to assess which ship recycling green business model would be the most profitable in Indonesia.

Jun-Ki Choi et.al (2016) [31] analyzed using a cost-benefit analysis and a life cycle assessment between standard and substandard ship recycling methods. Additionally, Zunfeng Dua et.al (2017) [32] found that in this study he used a three-step approach: interviews, fieldwork, and literature review. Firstly, in-depth interviews were conducted to gather information on the current situation, economy, international regulations and domestic laws regarding ship recycling in China. Secondly, investigated ship recycling docks, ship recycling processes, shipyard designs and conducted field surveys to obtain information on ship recycling yard equipment and facilities. Third, the literature was extensively used to corroborate the findings of interviews and field studies. Additionally, Kanu Priya Jain et.al (2018) [33] performed a detailed analysis using material flow analysis software to apply the concept of CP to ship recycling. A two-step methodology is used to perform such an analysis. The first step is to conduct a detailed study of the concept of cleaner production and its benefits. The second step is to assess the applicability of clean production to ship recycling and develop appropriate strategies to achieve the goals of this study. Also, E S. Ocampo et al. (2019) [34] employed a statistical study based on data collected from ships recycled in South Asia in 2016 and data collected from the Brazilian fleet likely to be recycled within the next 25 years. In addition to conducting interviews with maritime sector experts, shipyard stakeholders and shipowners, perceptions of this activity in Brazil were determined. Finally, Sunaryo et.al (2020) [35] compared the two business models and used the results as considerations for calculating project investment and choosing the best business model for green ship recycling companies. A feasibility study was conducted to assess the financial aspects of the two companies. Fixed and non-fixed operating costs and depreciation charges, number of ships recycled and expected revenue assumptions, 20-year operating cash flow calculations, and business viability calculations based on selected investment criteria.

Jun-Ki Choi et.al (2016) [31] shows that recycling ships by standard methods can be profitable. While ship recycling by standard methods may provide only marginal economic benefits, it is the most environmentally friendly option. In addition, coral reefs have the lowest economic benefit because there is no revenue from recycled materials. Furthermore, Zunfeng Dua et.al (2017) [32] found that no specific enforcement mechanism exists in the Chinese ship recycling industry from a comparison between Chinese law and international conventions. In addition, China should put in place a legal framework to clearly define the roles and responsibilities of different agencies. Thus, the ship recycling industry will be operated according to international conventions. Furthermore, Kanu Priya Jain et.al (2018) [33] showed that three strategies were identified, namely material flow analysis to improve ship recycling process planning, waste-to-waste conversion technology. energy to improve earnings from ship recycling and design. -for-recycling to reduce the cost of the ship recycling process. The proposed strategies are classified into two categories, yard-based strategies and ship-based strategies. Furthermore, according to E.S. Ocampo et al. (2019) [34], 97% of the global ship breaking market is in South Asian countries, while the remaining 27 ships are recycled externally, indicating a shift in the countries that dominate the industry. He also mentioned that Brazil's fleet could be recycled over the next 25 years, with about 340 vessels having a market figure of $587 million. Brazilian shipyards are an advanced technical and environmental sector of the Brazilian economy. Local and global stakeholders advise Brazilian shipyards to expand feasibility studies and acquire skills to promote local ship recycling. Finally, Sunaryo et.al (2020) [35] found that the most profitable business model for green ship recycling enterprises is the service provider model. From financial solvency calculations, the carrier model offers a faster payback period of 3.74 years, a higher net present value of IDR 228,322,021,477.88, a ratio higher average return is 0.36, higher internal rate of return is 17% and higher profitability ratio is 3.82.

2.4 Legal issues.

The EU regulation and Hong Kong convention were not entered into force yet. Because of a number of legal constraints facing the implementation of these regulations. The following parts includes 6 research activities from 2010 to 2020 focusing on the legal aspects of the ship breaking industry poor implementation.

Y. C. Chang et al (2010) [36], E. Yujuico (2014) [37], G. A.Moncayo (2016) [38] and J. I. Alcaide et al (2017) [39] studied the implementation issues of the Hong Kong International Convention, 2009" and Regulation 1257/2013 of the European Union focusing on the disadvantages and inadequacies of ship breaking activities on the coasts of Asian countries from southern. While J. I. Alcaidea et al (2016) [40] studied the impact of registering ships in convenient countries just before recycling their ships, this creates a loophole to avoid strict national legislation. and international rules. In addition, J. Hsuan et al. (2020) [41] investigated how existing ship breaking regulations affect supply chain management through inter-organizational arrangements, affecting mining and material recovery. materials for reuse, especially steel.

Y. C. Chang et al. (2010) [36] conducted legislative research for the Hong Kong Convention on how to find parties affected by control. In addition, E. Yujuico (2014) [37] conducted a case study of a need-driven, aid-based strategy examining the possibility of funding improved ship recycling processes in South Asia. In addition, G. A. Moncayo (2016) [38] conducted a forensic investigation into the cradle-to-grave approach and inventory of hazardous materials that a ship must keep on board until it is dismantled. are positive elements of the emerging ship recycling regime. In addition, J. I. Alcaide et al (2017) [39] introduced a statistical study through an online survey of battery owners looking for necessary amendments to existing international conventions. In addition, J.I. Alcaidea et al. (2016) [40] used a multivariate statistical technique known as "simple correspondence analysis" to conduct an empirical investigation to determine the relationship between countries and the ship breaking industry. Finally, a qualitative exploratory study of how rules affect supply chain management through agreements between organizations was carried out by J. Hsuan et al. in (2020) [41]. The study takes into account imports and exports and the economic and ecological value pairs that in many respects govern these inter-organizational arrangements.

A reporting system built by Y. C. Chang et al. (2010) [36] and an audit system is described to identify violations. In addition, E. Yujuico (2014) [37] presented a comprehensive sequential framework for this trade that governs relevant sustainability principles, environmental regulations, and economic justifications. In addition, J.I. Alcaidea et al. (2016) [40] examined the association between vessel registries selection and ships approaching the end of their useful life and re-flagging only for demolition. In addition, J. I. Alcaide et al (2017) [39] The results indicate that there are significant differences in the way the ship recycling industry perceives the upcoming ship recycling standards within the EU. Furthermore, Moncayo, G. A. (2016) [38] Although the Hong Kong Convention and EU Regulation 1257/2013 on ship recycling are acknowledged to have some positive aspects, it is suggested that they present a step back in ship recycling regulation. Finally, J Hsuan et al. (2020) [41] analyze inter-organizational linkages in the ship recycling supply chain as shown in Figure 5, this study argues that transaction cost analysis and agency theory are two complementary theories.

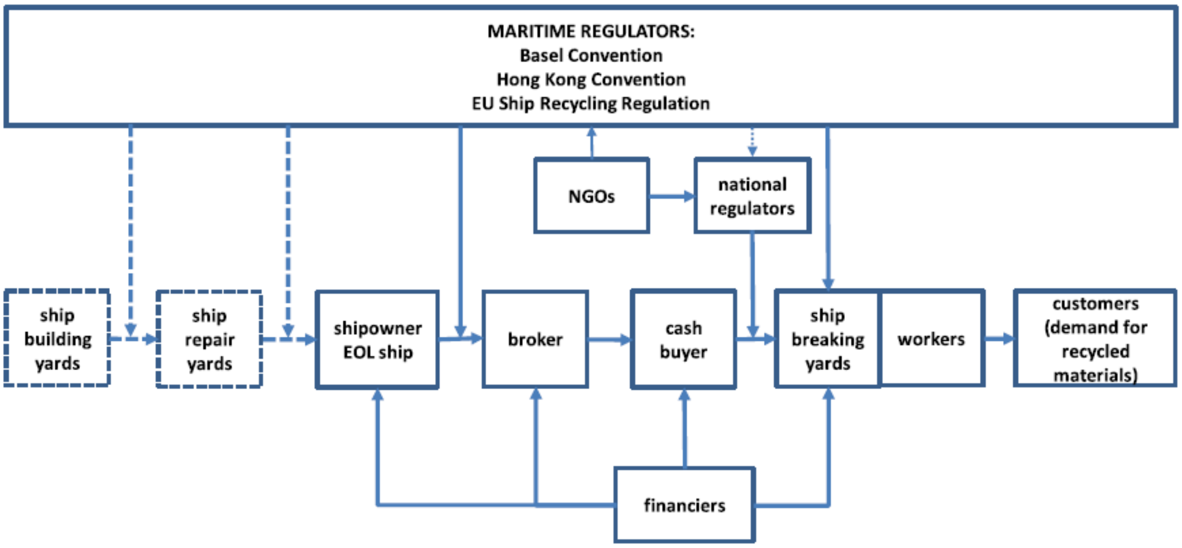

Fig. 5. The supply chain of ship recycling

2.5 Operations & Management.

The absence of specific guidelines for ship breaking and relevant information, results in decreasing the scrapping performance to the lowest level. The next paragraphs ranging from 2012 to 2020 includes 10 research papers which shows the defects facing the ship recycling industry due to bad management and operation.

K. Aoyama et al. (2012) [42] investigated the lack of specific instructions on how to dismantle substandard ships. While A. M. Hiremath et.al (2015) [43] points out that dismantling and recycling end-of-life ships in an environmentally friendly manner is a major challenge for shipowners, ship breakers and ship breakers alike. government agencies around the world. Furthermore, M. Sujauddin et.al (2015) [44] reported that the main obstacle faced by the ship recycling industry is the reluctance of stakeholders to disclose available but relevant information due to suspicions. suspected widespread. In addition, S.M. M. Rahman et al. (2015) [45] discussed the lack of coordination in the ship recycling industry in parts of Bangladesh and its effect on the flow of recovered metal resources. In addition, K.P. Jain et.al (2016) [46] also discussed bid spreads, but in this article the author focuses on estimating the weight of steel, as a percentage of possible light weight (LDT) based on the experience of the recycling site, or on expert opinion without resorting to any scientifically rigorous methods. In addition, S.M. M. Rahman et al. (2016) [47] discussed the environmental impacts, including the potential for global warming and the quality of human health and echo systems, due to other steel scrap handling practices. each other outside the construction site caused. In addition, K.P. Jain et.al (2017) [48], introduced that there is a supply price differential between "green" and non-green recycling yards due to higher ship dismantling costs due to compliance with international recycling regulations. and ship health, safety and environment (HSE Management System). While Jayaram S. et al (2018) [49] discussed the lack of a strategic direction plan for the ship recycling process in India as India is one of the leading ship recycling countries in the world and accounts for about 29% of the total number of ships. was recycled worldwide in 2017. Therefore, it is necessary to properly identify and allocate the responsibilities of the stakeholders to implement ship recycling in an efficient and sustainable manner. In addition, S. A. Gunbeyaz et.al (2020) [50] discussed how the operating costs of ship recycling yards will increase as new regulations are introduced, in order to survive in a competitive industry dominated by landfills. substandard and low cost. operating procedures must be performed. Finally, C. Benjamin et al (2020) [51] discussed how the number of studies targeting the Amazon region ship recycling market is incomplete and unsatisfactory. Furthermore, there is no plan to dispose of these vessels, which can lead to environmental and social damage and create business opportunities.

K. Aoyama et al. (2012) [42] conducted a simulation study of demolition on real ship structures. While A. M. Hiremath et.al (2015) [43] conducted a field survey to predict the emissions of 241 ships scrapped during 2011-2013 at the Alang port cluster while also predicting the amount of waste generated from dismantling. unloading of 6 types of ships (bulk carriers, bulk carriers, bulk carriers). cargo, containers, refrigerators and passengers). In addition, M. Sujauddin et.al (2015) [44] conducted a quantitative study of the data collected by visiting 20 shipyards, 3 rolling mills, 7 rolling mills in Chittagong. In addition to interviewing 400 private intermediaries to find out qualitative entries and exits from ship breaking yards. In addition, S.M. M. Rahman et al. (2015) [45] performed a statistical study using a questionnaire with a combination of closed and open questions, orally given to a number of representative groups to understand the relationship. relationship between social integration and resource flow. In addition, K.P. Jain et.al (2016) [46] conducted a quantitative study of the material composition of end-of-life ships using stability manuals and light-weight distribution documents on board. In addition, S.M. M. Rahman et al. (2016) [47] conducted LCA life cycle assessment to assess energy consumption and emissions when ships are transported from the country of origin for scrapping in Chittagong to recyclers. In addition, K.P. Jain et.al (2017) [48], discussed the general ship recycling process for bulk carriers (barrel ships), using material flow analysis. While Jayaram S. et al (2018) [49] undertook a study on a systems approach in the form of a linear scheme to implement ship recycling at a strategic level in India. In addition, S. A. Gunbeyaz et.al (2020) [50] performed a discrete event simulation study for alternative cutting technologies that were tested to evaluate their impact on production performance and cost. Finally, C. Benjamin et al (2020) [51] conducted a data analysis using fleet data from Brazil's national river transport agency for 5319 dismountable vessels.

K. Aoyama et al (2012) **[**42**]** proposed a planning system for a suitable ship-breaking process that considers worker safety and environmental as well as economic issues. Also, A. M. Hiremath et.al (2015) [43] provided the knowledge-based needed by individual yard owners for planning their short term and long-term activities in order to serve as an essential part of the management information system which will help in governance of cluster of ship dismantling yards. Moreover, M. Sujauddin et.al (2015) [44] found that the Oil tankers and bulk carriers have been preferred by Bangladesh's ship breaking industry because of their higher steel content. Moreover, introduced that by keeping organized records is critical to develop a comprehensive understanding of this industry. It was noticed that all of S.M. M. Rahman et al (2015) [45], K.P. Jain et.al (2016) [46] and K.P. Jain et.al (2017) [48] introduced a suitable tool to analyze and plan the ship recycling process using MFA for better waste management and resources in order to reduce cost. On the one hand, S.M. M. Rahman et al (2016) [47] suggested that a clear environmental benefit exists in recycling steel from ship scraps, relative to the use of steel from virgin ore. On the other hand, Jayaram S. et al (2018) [49] developed A guidance plan based on the present practice in the Indian ship recycling industry, new regulations and other factors which can improve the industry for achieving sustainable development and assist the stakeholders, especially the shipowner and the ship recycling yards, to coordinate and to execute various activities in an efficient manner during each stage of ship recycling. Besides, S. A. Gunbeyaz et.al (2020) [50] found that plasma cutting is a good alternative to oxyfuel cutting which used in cutting operation in the secondary zone of the ship recycling yards. Finally, C. Benjamin et al (2020) [51] found that Between 2005 and 2015, many vessels were built as a result of the boom in the shipbuilding industry, and these vessels will generate a significant growth in the ship recycling market starting in 2025 with an exponential trend as shown in figure 6. It means that two concentration poles of potential vessels exist in Brazil. One pole is in the north of the country and is linked to the considerable volume of vessels in the Amazon region and the lack of destination procedures and regulations for obsolete vessels. The second pole is in the southeast and is linked to the offshore market, under the influence of Rio de Janeiro.

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Fig.6. Projection of potential ship recycling market for the next 20 years in Brazil (Reference year: 2017).

3. Best Practices for Ship Scrapping

There are four methods for ship recycling "Beaching", "landing", "alongside" and "docking", the first one is refused from the HKC convention due to the large amount of hazardous materials which are landed on the mud. The next two methods also causing marine pollution but less than beaching method. While, the fourth method is the best practice for ship recycling which is applied inside the dock land but it needs large area with high cost.

4. CONCLUSIONS:

In this article, a Systematic literature review of 51 studies during the period from 2010 to 2021 on ship recycling was made. This literature analysis helps identify the top countries, the most popular journals, researchers and their collaborative links. The literature review further identified the categories of research studies and the methodologies employed. An analysis of the reviewed articles also identifies research challenges and directions for future research. In this way, this article provides a brief summary of the advances in ship recycling through scholarly publications. The main conclusions of this study are as follows:

- Top leading countries in ship recycling industry are Pakistan, India, Bangladesh, China and Turkey.
- 5 research categories have been defined:
    - Design consideration
    - HSE impacts & challenges
    - Economic Aspects
    - Legal issues
    - Operations & management
- there is a lack of research activities related to a number of topics.
    - There are only 7 published papers for the Design considerations in ship recycling industry topic, including design for recycling, green ship recycling yard layout design and recycling procedure design.
    - There are only 5 published papers for the economic research activities which may contribute effectively to the solutions of the problems facing the ship recycling industry.

- Egypt is one of the rich coastal countries, through which Suez Canal passes and surrounded by red sea and Mediterranean Sea, but it was found that there is an almost no research activities published in regarding with this industry implementation in Egypt.
- There is a gap in research activities regarding to the merging among traditional ship recycling methods, operation and management studies, environmental impacts and economic feasibility studies.

The findings of this analysis can be used by decision-makers to learn more about research collaborations, groups, and directions. The direction of upcoming research investments could be influenced by this information. Focused, innovative research can be conducted with the help of the identified and analyzed research studies, methodological difficulties, and suggested research directions. Therefore, it is anticipated that this review paper will aid in the development of research ideas, cutting-edge technical approaches, and general ship recycling advocacy. Future review studies might take into account some targeted research questions or concentrate on a more in-depth examination of any subject under consideration in this review paper.

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SIFLOW21. PREDICTIVE SIMULATION OF NAVIGATION CHANNELS AND PORT INFRASTRUCTURE CAPACITY WITH AUTOMATIC IDENTIFICATION SYSTEM (AIS) DATA ASSESMENT

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Keywords: Traffic Flow simulation, port efficiency, AIS data, Risk Assessment.

1. **ABSTRACT:** Port development projects require reliable data for cost-benefit evaluation of the investment and selection of the best alternative. The objective of the analysis is to confirm that they will respond to the future capacity of the port together with an adequate safety/risk level, optimizing the dedicated resources. A methodology is described combining a mathematical model of traffic forecast with the evaluation of nautical risks. As a result, it allows to establish the service&safety level of the navigation channel or the new infrastructure and to set the basis for decision-making. SiFlow21 is a predictive simulation model for maritime traffic, developed by Siport21. It allows to quantify the movement of ships in the waterplane area of a port. It takes into account the topology of the port, the various traffics with their particular volume and seasonal distribution, the navigation rules, tidal conditions and local maritime climate. It is extremely versatile to adapt to channels and ports that can become very complex.

2. INTRODUCTION

Port infrastructure development projects require reliable data for the cost-benefit evaluation of the investment and the selection of the best alternative [1]. The dredging works to deepen port access channel are an outstanding example to illustrate this kind of projects. The objective of the analysis is to confirm that these development projects respond to the planned capacity of the port in the future, providing admissible congestion levels, together with their level of safety/maritime risk, optimizing the port resources and, therefore, the associated costs [2].

At the request of several international entities and companies, Siport21 has developed a very versatile mathematical model, which is able to complete this kind of analysis in a wide range of complex environments and with different types of traffic. Siflow21 (Maritime Traffic Flow Simulation) allows reproducing the movement of ships in a navigation channel or port area considering their specific characteristics. The construction of the model includes as a first step the calibration against the real situation described by the AIS (Automatic Identification System) data [3] [4], and detailed port terminal data, which ensures its reliability. Thus, future scenarios are compared with the current situation based on the definition of a set of evaluation indices. These refer to both service levels of the port or waterway (congestion, delays, use of resources, ...) and safety levels (risks of grounding, collision, ...).

To determine safety levels a preliminary assessment of the individual risk per ship type based on different parameters (manoeuvring models, navigation areas, encounter & grounding areas) is required. Further on, with the SiFlow21 results the future risk levels can be estimated based on the infrastructure and operational modifications together with the increase in the number of ships, encounters, overtaking, … [5] [6]

3. METHODOLOGY

The methodology applied combines a mathematical model of traffic prediction with the evaluation of nautical risks, thus allowing to establish the optimum safety&service [19] levels of the navigation channel or the future port infrastructures (basins and/or berths).

These studies typically start with the AIS data analysis, allowing to accurately describe quantitatively the traffic movements in the current scenario (type of vessels, number, sizes and drafts, routes, speeds, crossing / overtaking manoeuvres, anchorage operations, scheduled calls, seasonality, traffic interferences, berths occupancy, etc.). Given the enormous volume of data (millions of records each year), the analysis is based on Big Data, Data Analytics and DataViz techniques [7] (algorithms to identify space-time relationships between the different traffics and physical conditions with advanced representation methods).

The AIS data analysis allows defining most of the inputs required for the accurate building of the maritime traffic simulation model (base model). Siflow21 is an in-house predictive simulation model of port capacity. It allows to accurately quantify the movement of ships in the port waterplane, taking into account the topology of the port area (access channels, berths, basins and anchorage areas), the different types of traffic with their particular frequency, seasonal distribution, navigation rules (DST, priorities, maximum speeds, minimum UKC, Pilot or tug assistance, crossing rules, ...), the tidal conditions and the local maritime climate; all of this with a great versatility to adapt to channels and ports that can become very complex.

The program modules describe the different system components with their particular attributes and the interaction among them. Once the system is defined, ship arrival/departure processes are launched according to the observed statistical distributions [8] (AIS data) and tackling current navigation regulations.

Once the model is built, it is calibrated against real data (mainly extracted from the AIS analysis and other available sources). Then, future scenarios are described and quantified (infrastructure works, new terminals, changes in navigation rules, increase in traffic volume). The different scenarios are simulated using a random method that covers typical periods of one year. The corresponding quality and safety KPIs [9], defined ad-hoc for each specific project, are computed. In this way, a reliable assessment of the future situation is available as a basis for decision-making.

This methodology has already been applied in numerous cases: Bahía Blanca (Argentina), a project to expand the channel in a long estuary operating with tidal windows, interference with LNG traffic (channel priority); Buenaventura (Colombia), cost-benefit of an expensive deepening project; Río de La Plata-Hidrovía (Argentina), with demanding draft limitations, new traffic, increased volume; Guadalquivir River (Spain), optimization of operations, increase in capacity of the fairway without dredging, rescheduling of manoeuvres; bays in the Philippines, with high anchorage congestion in mixed traffic areas; Tarragona (Spain), new terminal close to the port access channel, interference and risk assessment. Some case studies and the benefit of the results obtained are shown.

3.1 AIS data analysis

The AIS system [3] [4] allows the identification and tracking of ships, automatically, from other ships, or coast stations. This system is based on a device installed on board that continuously and automatically transmits information that allows other ships in the area or onshore stations to identify them and to find out their position and movement parameters.

The AIS has been developed under the auspices of the International Maritime Organization (IMO) and its installation and use in ships, subject to the SOLAS Convention (Safety of Life at Sea), is mandatory since December 31, 2004. The vessels obliged to incorporate these devices are:

- All vessels on international voyages with a gross tonnage (GT) greater than or equal to 300
- All vessels on non-international voyages with gross tonnage (GT) greater than or equal to 500
- All passengers regardless of size

The AIS equipment emits messages containing data related to the position and state of the ship movement with a variable periodicity depending on the navigation status, speed, and the manoeuvre she performs.

Once the quality and reliability of the available AIS data has been verified, a large number of variables are analysed in order to know with a high accuracy level the behaviour of maritime traffic within the port system, as well as to define the input data required for the maritime traffic simulation model [18]. Some of the most relevant variables in this type of studies are listed below:

- Analysis of ships during navigation:
  - Type of vessels according to cargo and size

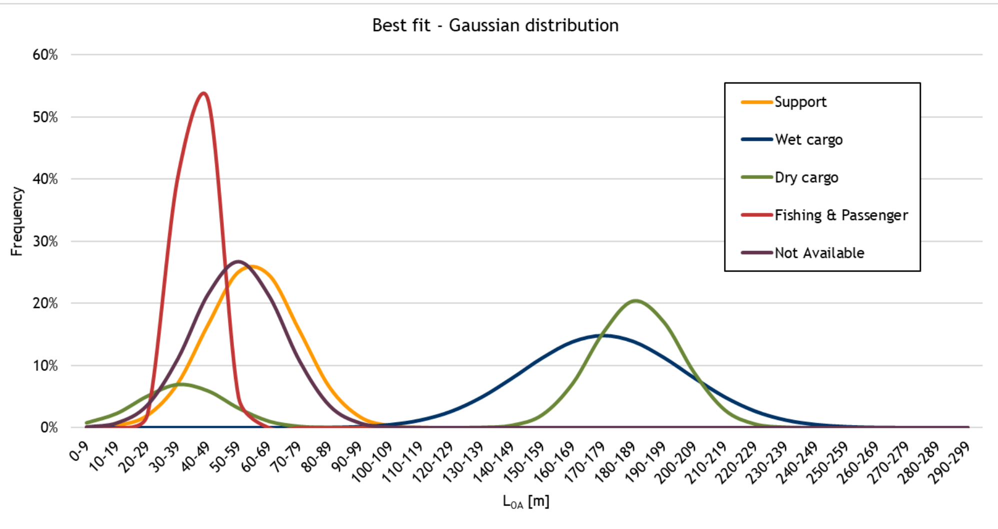

Figure 1: Vessels size according to the cargo. Source: Siport21

  - Calls frequency and seasonality (cruise ships, for example)
  - Crossing / overtaking manoeuvres: if any, location and frequency of these events, combined dimensions of meeting ships, speed and distance, etc.
  - Manoeuvring strategy: waiting, turning areas, navigation speed, use of tugboats

- Load condition based on access or departures and, therefore, type of operation (import or export)

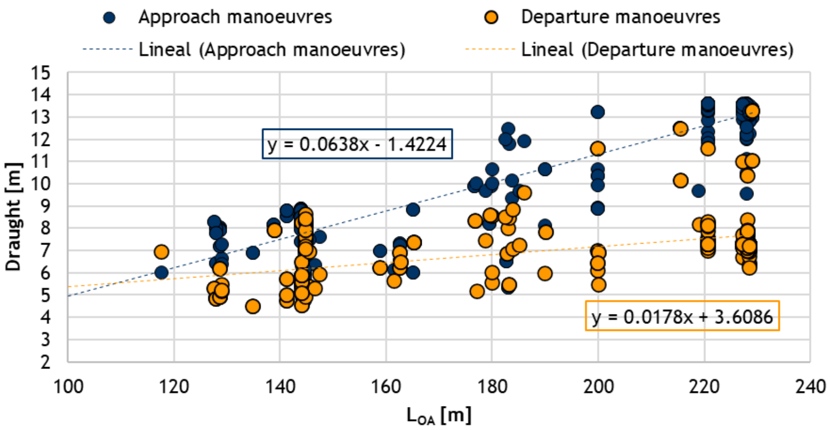

Figure 2: Import and export operations analysis. Example of loading condition for approach and departure manoeuvres. Source: Siport21

- Vessels' route: access channel to the system, exit channel and intermediate points (anchorages, terminals)

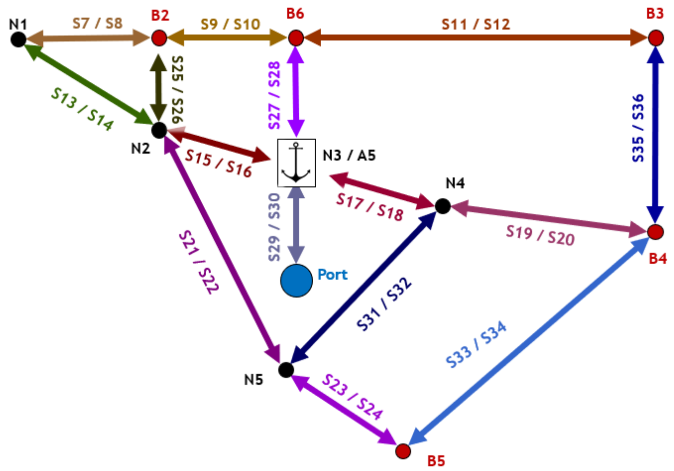

Figure 3: Route analysis. Example of a ship route in a complex system. Source: Siport21

- Analysis of ships at anchorage:
  - Frequency of anchorage operations (ratio anchoring vessels/ total vessels)
  - Type of vessels that usually anchor (cargo and size) and priority traffic (unusual anchorage, direct access without waiting)

- Time spent at anchor depending on the type of vessel
- Anchorage preferences: area in which ships usually anchor depending on the type of ship (cargo and size) and terminal
- Occupation of the anchorage areas (average occupied area, number of simultaneous vessels)

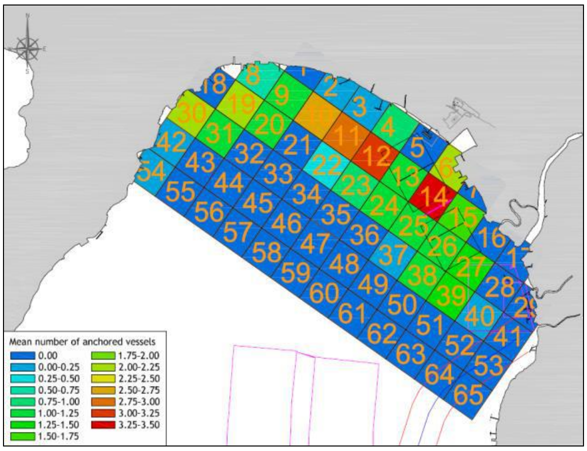

Figure 4: Occupation analysis of anchorage areas. Example of a bay occupation map. Source: Siport21

- Analysis of ships at berth:
  - Type and size of vessels that access each terminal
  - Occupancy level of the terminals

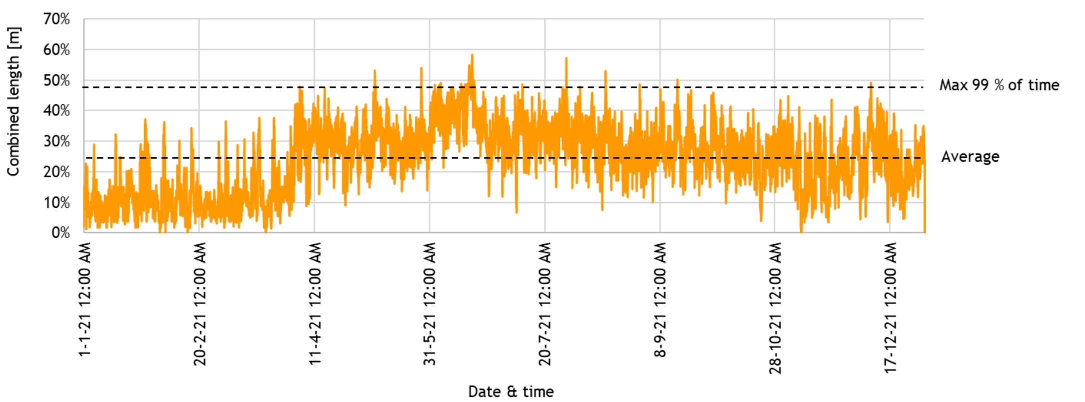

Figure 5: Occupancy level time series. Source: Siport21

  - Time spent at berth depending on the terminal (efficiency of loading / unloading equipment), cargo and size of ships

The results of the AIS data analysis can be collected in a wide variety of graphs, from point clouds to single track plots, occupancy density maps ("heatmaps") or position distributions.

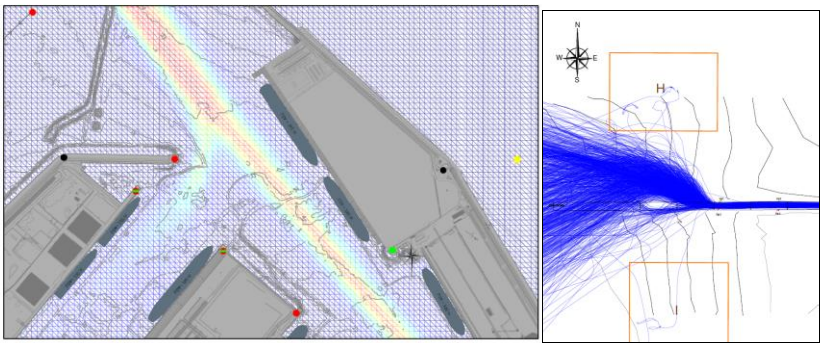

Figure 6: Occupancy density of port areas (left) and access trajectories to a navigation channel (right). Source: Siport21

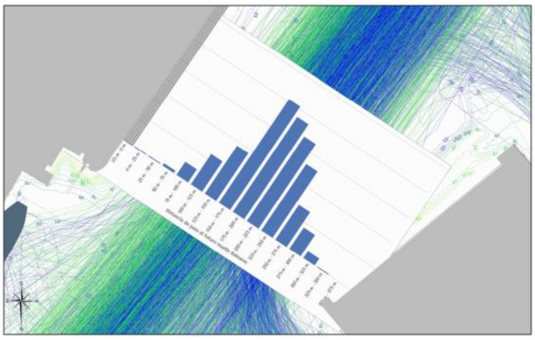

Figure 7: Geometric distribution of vessels in a relevant passage section. Source: Siport21

3.2 Definition of Key Performance Indicators (KPIs)

In order to facilitate decision-making, a series of key indicators is defined that will allow different future scenarios to be compared with the current situation. The KPIs (Key Performance Indicators) [9] must be aligned with the objectives and particularities of the project. In addition, the same indicators will serve as the basis for the calibration process of the maritime traffic model.

After calibrating the maritime traffic model and analysing the different scenarios proposed, the ad hoc indicators are elaborated, and the advantages and disadvantages of the different measures considered (infrastructure projects) are compared.

The most common indicators in this type of studies are those referring to the efficiency of the port system. However, there are other indicators such as risk or economic indicators that may be relevant in decision-making [10].

Some examples of the most common key indicators are highlighted below:

- Related to the use of the terminals: the occupation of the terminals as well as the fraction of time that the ships remain berthed and are not waiting (efficient time at berth) are indicators of both capacity (extra margin of the terminals to absorb more traffic) and efficiency (demurrage in the terminals).

- Related to the use of the anchorage areas: as with the terminals, the occupation of the anchorage areas also indicates the capacity of the system (extra margin of the anchorages to absorb more traffic). Likewise, higher use of anchoring areas indicates greater congestion and, therefore, less efficiency.

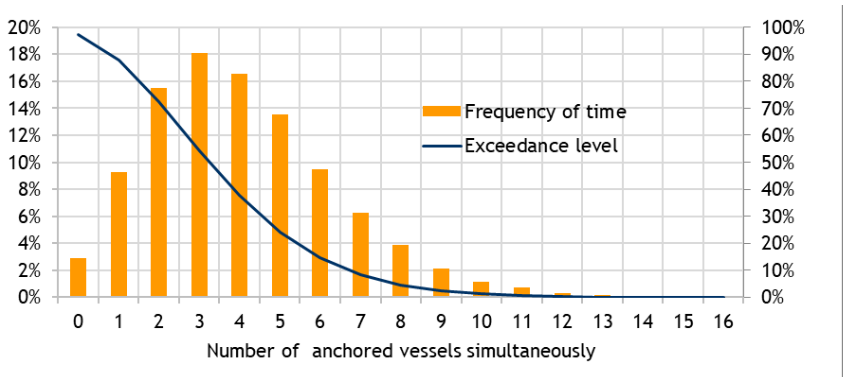

Figure 8: Indicators related to the use of anchorage areas. Simultaneously anchored vessels. Source: Siport21

- Related to the vessels that access the system: waiting times, depending on their size, draught, cargo and target terminal:
  - Average waiting time
  - Area where they wait
  - Reason for waiting. Bottlenecks identification [11]
- Related to economic income: if enough information is available, the economic income derived from nautical activities can be estimated, such as port entry fees, use of the VTMS service, use of anchorage, terminal, pilotage, towing and mooring fees.

3.3 Model building

The model building consists of defining and characterizing the following elements, which make up the creation of a navigation system:

- Vessels: all the characteristics of the vessels to be generated are described in this module to create a random arrival sequence close to reality (according to type: destination, arrival patterns, route to be sailed, destination, minimum time at berths, …). The time it takes to navigate each section of the channel is also defined, linked to navigation speed (according to type/size of vessel, approach / departure). This module also determines how many ships are generated according to the type of fleet and how the arrival time varies between ships, including seasonality.
- Static elements of the port:
  - Terminals. Points where the ships access, remain for a determined minimum time required to carry out the loading / unloading operations and wait in the terminal before starting the departure manoeuvre, only if needed. The main parameters are the maximum number of simultaneous vessels, the berthing length available and the depth.
  - Anchorages. Points where ships wait, only if needed. It is also possible to require ships to wait a minimum time before continuing their route for carrying out any kind of activity such as pilot

boarding. The main parameters are the maximum number of vessels anchored simultaneously, the available anchoring area and depth, as well as special anchorages (dangerous cargo, for example).
  - Channel sections. These are the sections transited by ships between elements of the port (channel to anchorage, anchorage to terminal, etc.). The depth and the maximum number of vessels that can navigate simultaneously through a section of channel are defined.
- Navigation rules (traffic control, Pilots). This extensive module describes (for each navigation area and ship type) the rules applicable to crossing and overtaking manoeuvres, minimum distance during navigation and minimum underkeel clearance. Finally, the environmental limits (tide, wind, current and waves) are also included.
- Wind, wave, and visibility conditions: annual/seasonal distributions of wind (direction and speed), waves (direction, period, wave height), and visibility (good or bad) are described in this module, representing the local climate.
- Tide and current: the variations of the water level and current intensities are defined in the different elements of the system (terminals, anchorages and sections of the navigation channel) throughout the year.

3.4 Simulation

Once all the modules of the model have been defined, the simulation process starts with the 'vessels' module, random generation of vessel arrivals based on statistical distributions tuned to the AIS data. After the generation of each ship, the restrictions along its pre-defined navigation route are checked. The checking process is as follows:

- Regulations are checked at the closest port element where the vessel can wait (water level and availability/capacity).
- Once the feasibility of waiting at the closest possible port element has been verified, the regulations are checked during the route from the current position to the mentioned waiting point. In each section of this route, the regulations are verified:
  - Crossing events: based on the navigation area, vessels type and size, the crossing is allowed or not.
  - Minimum safety distance: to the nearest vessel, depending on the type and size of the vessels.
  - Minimum under keel clearance.
- In case there are restrictions:
  - During the route to the nearest waiting point, the vessel will wait before starting its navigation until this navigation is feasible in compliance with the applicable regulations.
  - At the closest waiting point: the vessel will wait before beginning its navigation through the corresponding sections until waiting in this area is feasible in compliance with regulations or until complete navigation to the next waiting area is feasible.

This verification process is repeated along the complete route of the ship. The terminals are considered as a point where ships can also wait. However, unlike anchorages, ships must remain for a pre-defined service time in the terminals (whether they wait there or not).

Once the model is built, the calibration is carried out running the model in an iterative process of simulation - analysis of results - adjustment until reaching results close enough to reality. The calibration process is always carried out based on a real scenario, from which information on the behaviour of maritime traffic is available with an adequate level of detail and accuracy.

The level of detail required to achieve reliable results is based on the analysis of AIS data. However, there is some information that cannot be extracted from its analysis, such as the actual draft or the causes of waiting events. Therefore, it is advisable to consult additional sources and hold interviews with local experts who can expand the available information.

3.5 Alternative scenarios assessment

In general, the new alternative scenarios of interest will be those that have an impact on the current traffic flow, such as increase in traffic volume, changes in infrastructure (new terminals, channel expansion dredging, additional entrances, ...), new regulations (VTS, traffic separation schemes (TSS), organization of anchorages, crossing, minimum UKC, assignment of Pilots or tugboats, ...), new types of significant traffic for the port system (for example, LNG import), etc.

Once the model has been built and calibrated, the results of the current situation are used as a reference for the comparison of the KPIs of the alternative scenarios. Siflow21 is a very versatile tool that allows to adapt the model and include various changes in order to assess their impact (positive or negative) on traffic behaviour, based on the key indicators defined for each study.

On the other hand, and with the objective of analysing the impact of relevant changes in the traffic flow not only in the short term, but throughout a certain period of time (lifetime of a new infrastructure, for example), a minimum of 3 traffic volume scenarios must be analysed in order to allow interpolations with an adequate level of precision.

The traffic volume for future scenarios is defined through forecast studies, considering relevant information such as historical evolution of traffic, investment needs and capacity improvement, master plans for expansion of current facilities and planning of new terminals [12].

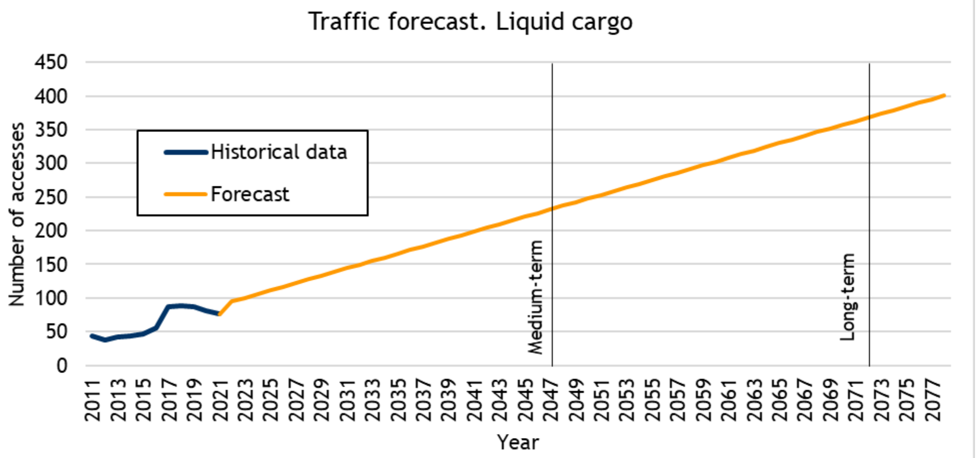

Figure 9: Example of traffic forecast based on historical data. Source: Siport21

The analysis of several traffic volume scenarios also allows to determine the capacity of a given infrastructure scenario (maximum number of vessels that can access the system), under congestion acceptability criteria (waiting times) according to the type of traffic. This process makes it possible to establish recommendations regarding the most appropriate corrective action, at the most appropriate moment.

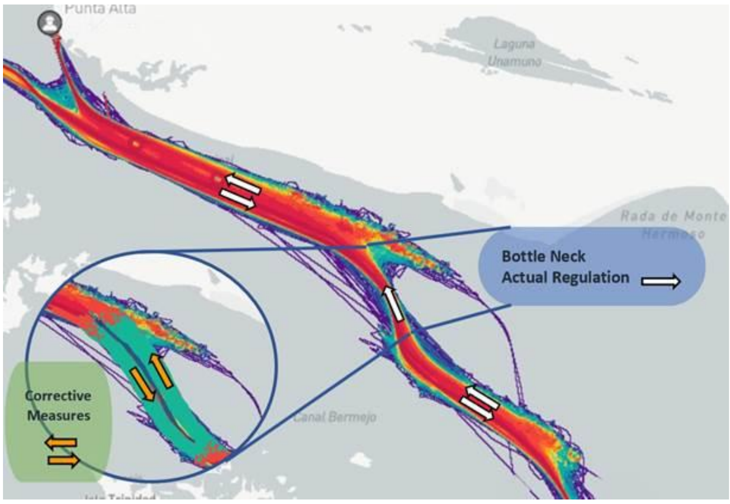

Figure 10: Example of corrective measure (crossing area, double lane) for a scenario with high congestion levels (single lane area). Source: Siport21

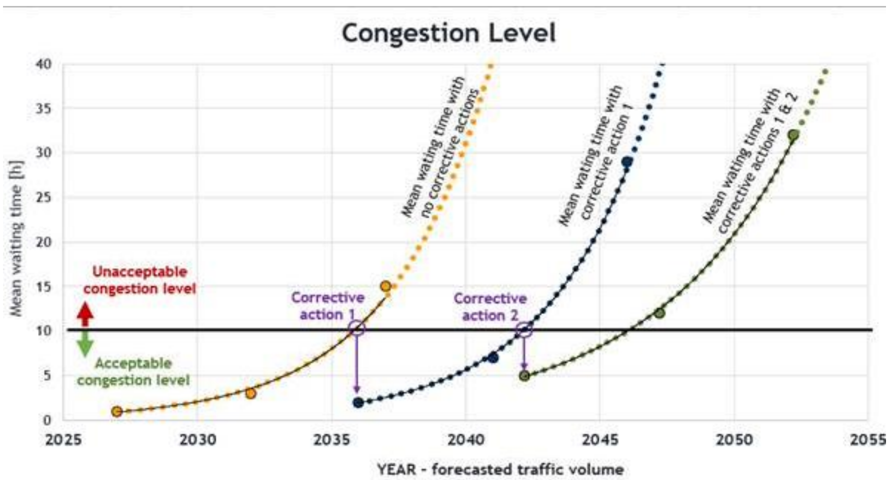

Figure 11: Example of application of corrective measures at the optimum application time (unacceptable level of congestion). Source: Siport21

Based on a preliminary assessment of the individual collision and grounding risk per ship type and size in the different channel stretches and port area, it is possible to estimate the future global risk of the navigable area based on the future number of accesses per each ship type and size, and the number of estimated encounters/overtakings for each of the alternate scenarios.

Finally, the combination of key indicators results allows to determine the optimum combination of actions on the scenarios, establishing adequate combined levels of congestion and safety for nautical activities [13] [14].

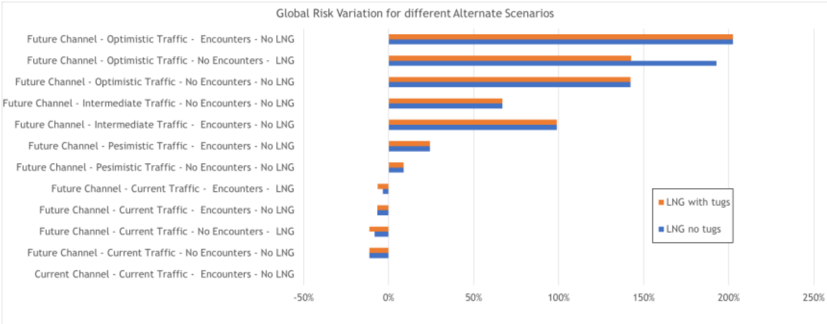

Figure 12: Nautical risk assessment for the alternative scenarios. Source: Siport21

4. CONCLUSIONS

The methodology described involves carrying out studies with a high level of detail in order to accurately reproduce both current and future scenarios, by means of a verification process of the reliability of the results. Likewise, Siflow21 model allows many variables to be introduced as input parameters that precisely define the reality of maritime-port traffic systems with high complexity. As a result, the optimum safety&service can be given for any complex maritime system for both, current and future scenarios. Some of the most relevant case studies, due to their innovation or relevance, are shown below:

- Channel deepening project. When access to a navigation channel is determined by the tidal level, one of the most effective measures to reduce waiting events is to deepen the corresponding navigation areas to increase the tidal windows. In this sense, maritime traffic simulation makes it possible to find out to what extent a given dredging project reduces traffic congestion and, likewise, determines the capacity of the new dredged channel (how many more ships per year can access after dredging). A balance point is sought between the dredging depth (with the corresponding cost) and the operating gain due to the reduction of demurrage.
- New dangerous cargo terminals. The LNG transport, especially, entails the implementation of a series of strict and specific safety measures. One of the main concerns is, therefore, the possible effect that this new traffic may have on the general behaviour of a given port.
- Enabling of crossing areas. Crossing areas are frequently applied to reduce congestion. However, these are critical areas in terms of nautical risk. Maritime traffic simulation studies support decision-making, finding the optimum point for congestion reduction while keeping safety level.
- Rearrangement of anchorage areas. There are port systems, such as bays or refuge areas, in which anchorage operations represent a common and important operation. As the volume of traffic grows in these areas, it is common for the anchorage operation, to evolve into more chaotic and optimizable situations. Different criteria for rearrangement of the anchorage areas can be simulated, also including changes in the regulation. This evaluation can achieve a substantial improvement not only in the efficiency of the system, but also in nautical risks.
- Global or individual increase in traffic intensity (number of arrivals). In terminal expansion projects that involve a significant increase in the number of calls or access for larger vessels with

more demanding restrictions (draft, towing, weather limitations), the impact of this increase on system congestion can be assessed. The same can be said of an organic increase in port traffic.

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THE OUTCOME OF IMPLEMENTING STRUCTURED SOFTES MODEL AS A POST SIMULATION DEBRIEFING STRATEGY AMONG MARINE TRAINEES

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Keywords: SOFTES - Simulation Training - Self-Analysing - Self-Evaluation.

1. ABSTRACT: This research studies the impact of implementing the structured SOFTES model as a debriefing strategy after the simulation training on marine trainees. One hundred trainees were split to two groups, each group was fifty trainees and took a questionnaire that was used to collect data. The experimental group was trained on the SOFTES model with its simulation training and the control group took the normal training only. SOFTES model is examined through multiple factorial elements, which are; Student, Objectives, Facilitator, Time, Environment, and Skills competency. Descriptive analysis was used for variables and comparing analysis using the T-test was used to study the effect of SOFTES model on the self-analysing and self-evaluation of the trainees from two groups and indicate which group has better behaviour in analysing. The impact of implementing the SOFTES model on the trainees' self-analysing was showed as a positive and significant. Also the difference between means was showed which indicates the experimental group has less anxiety and increased self-confidence than the control group.

2. INTRODUCTION

Human error is widely acknowledged as the most significant contributing element to accidents by maritime stakeholders. Dangerous acts, failure to act, behaviours, unsafe conditions, or a combination of these are examples of human error. 70% of accidents were happened by human errors as mentioned in reports from some countries. The International Maritime Organization (IMO) established the basic requirement that the instructors or facilitators must trained very well. To be qualified and competent to conduct such tasks, before each officer takes his tasks on navigational watch, the training must be complete ashore. As a result, the level of safety on board ships will rise (ELASHKAR, 2016).

The simulator provides a free environment from risks for learning how to treat hard scenarios or dangerous scenarios, the shipping industry is careful about training the officers on simulators because it is safe. The new technologies can provide modern simulators that can perfectly reproduce real-world events. So, the new technologies played an important role in developing training programs based on simulators, that depend on the trainee is keeping the information and is learning perfectly if he feels, looks, or acts like the real thing. The simulator refers to the representation of the truth (Wahl, 2018).

It is proven that training maritime officers using simulators on the shape of ships is successful in learning. While the simulation, it is important to care about the timing of each step, which means should be one second in simulation equals one second in reality. This refers to manoeuvre experiments taking a long time in training despite all advantages of simulation, for example, a berthing manoeuvre training session might spend an hour. So if the trainer needs a second try for sessions (if the first way failed or needs to try a different way), it will take an extra hour, which is not particularly effective (Benedict et al., 2017).

Implementing trainee centres that focus on trainees and changing the focus from technical accuracy to accuracy in analysing the complete training is the most important point. After analysing the simulator's social organization, it is shown that increasing awareness of the interactional aspects of simulator training is important to every trainer (Wahl, 2018).

SOFTES is the model used in this research. SOFTES model is defined as including self-evaluation, self-reflection, and self-analysing of the trainee after the simulation. Explain the word SOFTES in detail where S points to students and all things related to students including their interpersonal skills and characteristics of students. Then O points to the objective and if the objective of the simulation is achieved. F points to Facilitators or instructors and how instructors supervised the trainees.

T points to the time or duration of the simulation and if the duration of each step was enough or not enough. E points to the environment and whether it simulates reality or not. Finally, S points to skills competency and whether students gain the skill and the purpose of simulation or not. SOFTES helps trainees in self-evaluating and helps to improve the next scenario of simulation (Shalaby and Hassan, 2019).

The result of using a structured SOFTES model as a post Simulation debriefing strategy among marine trainees is the purpose of this research.

3. LITERATURE REVIEW

Bobrysheva et al. (2022) aimed to examine the efficiency of training using engine room simulators and to show how it relates to a trainee's time at sea, ownership of a maritime license, and prior experience with other simulator types. The many engine room simulator types have been assessed by several trainees who took graduate and post-graduate marine engineering courses. Various simulator types have been taken into consideration. Numerous inferences have been made after comparing the trainee perspective with the findings of the objective assessment. The findings indicated that because 2D simulators provided an understanding of the functioning principles of whole engine room systems and their interdependencies, they may be very useful teaching tools for students in the early stages of their education. This type of simulator may also be useful for planning the operational principles of all engine room systems and their interdependencies. Additionally, useful for preparing operational procedures during resource management courses and management-level education in general.

A virtual reality ship command bridge was compared to maritime training simulator needs by Luimila et al. (2020). A VR experience centered on the STCW competency for ship steering was developed as the technique. We were able to pinpoint a number of problems with our VR teaching environment thanks to the test, which was conducted with 16 seasoned sea captains. A threat to the trainees' physical safety was present, along with unnatural controls, inadequate HMD resolution, ship behavior limits, a lack of engagement with the trainer, a lack of documentation for insightful debriefing sessions, and ship behavior restrictions. The findings showed that our training application was not up to par with all simulator criteria, but they also made it evident that each issue could be resolved with more advanced hardware and reliable virtual reality programming. In light of these conclusions, it can be said that virtual reality is a reliable, affordable, and efficient training medium for command bridge simulators.

The goal of Shalaby and Hassan's (2019) study was to examine the results of applying the SOFTIES model to the debriefing process used by nursing students. An evaluation of the SOFETS model's efficiency was carried out after holding an orientation day for the students. The results demonstrated that using the SOFTIES model with trainees improved their perception of their value as people and their level of satisfaction with their education, which was discovered in the earlier study when using simulation. There is no difference between using and not using the SOFTIES Model as a result.

Zhang et al. (2019) intended to ameliorate the training program for marine trainees in maritime operations. Three methods were adopted for analysis which is a questionnaire analysis was used, then a measuring scale to ensure the significance of visual focus in training, and finally similarity metric was adopted for estimating between saliency and optical transmission. The population was separated trainees into two groups, one of the two groups obtained less information than the other group. The result exposed that the group with more information achieved higher scores than the other group. Thus, the more information the group has, the higher performance is accomplished.

Jia et al. (2019) aimed to enhance the efficiency of the trainees in virtual reality training. There were two approaches to achieve the main aim of the study, an offline questionnaire was collected from 60 persons who answered the 10 short answer questions. The questionnaire was gathered two times one of them before the test and the other after the test to compare the efficiency of the training. The second method used was the 60 persons who answered the questionnaire spilled into 10 groups and did the virtual training ship. The result investigated the trainees' effectiveness convinced in virtual training which helped them use navigation.

Linnervuo et al. (2019)'s investigation attempted to find out how simulators may make navigation and tactical training more professional. They also looked at how simulators could be used in maritime training to benefit from cost-effectiveness, repeatability, and security. Survey responses were gathered from both sailors and sea cadets. The results showed that efficiency plays a big part in putting simulation training with marine trainees into practice.

Maung (2019) aimed to investigate the dissertation and critically evaluate the adoption of a required simulator-based training and evaluation program for seafarers' competency certifications in Myanmar's MET system and how it can help produce quality seafarers quickly. A feedback survey from different students and universities was used. The result revealed simulators were not the ideal training and evaluation tools. However, simulators could be used as a tester for justifications that the anticipated outcomes of marine education and training (MET).

Haavardtun et al. (2019) sought to advance our understanding of how simulator fidelity affects training efficacy in marine education and training. The study looked into the effects of two different simulator models on how students participating in engine room simulation training assessed their skill growth. The self-efficacy levels and perceived skill advancement of eleven second-year marine engineering students were examined on two fidelity engine room simulators. The results demonstrated that when employing immersive training simulators as opposed to traditional education, students were more motivated to learn.

Simulator use in current marine research was examined by Ostens and Zghyer (2019), who also outlined the benefits and drawbacks of doing so in the maritime sector. After doing a literature review of relevant studies using simulators, the next step was to interview experts and researchers in the field. The results suggested that employing simulators in the maritime sector might be secure, practical, and at the cutting edge of modern technology.

Myhrvold et al. (2018) purposed to define the types of training for the sake of preparing the complex tasks in marine training, the study adopted objective performance measures to analyze the trainees' performance. The study spilled the trainees into groups: the first group with symmetric current and the other group with non-symmetric. The result revealed that complex tasks shouldn't include in early training. Another finding detected that functional fidelity simulation raised the level of trainees' performance, especially during complex tasks.

Wnag et al. (2018) sought to investigate the prevalence of seafarers' emotions and how these affected their performance using a bridge simulator. The two key elements of the technique were test recognition and emotion calibration. Seafarers' feelings during maritime operations, related to events uncovered, have an impact on their behavior and decision-making, according to officers' emotional responses during a test on a bridge simulator. A negative mood was also more likely to contribute to mistakes than a happy feeling. Lower degrees of negativity are the most perilous emotional state for navigation, followed by high levels of positivity.

Al Shahin (2017) examined how marine simulators affected training. A comparison of training technologies is presented to shed light on potential technological substitutes for simulators. A few pieces of literature were found when searching for the effects of marine simulators on training. Simulated training regularly produced significant training results, according to research from service and training institutes.

Sellberg and Lundin (2017) examined the use of simulators in maritime education, paying particular attention to how navigation teaching was carried out in virtual settings. The first episode provided a bizarre case in which a decision was made and then evaluated, whereas the second episode displayed characteristics common to the other episodes in this group in which decisions were made and then analyzed. This decision was made in light of the outcomes of the study on collaborative interaction. The small sample consisted of one instructor and four Master Mariner trainees. The results showed that instruction in simulations was a constant interactional success based on the ability to determine whether the evaluation criteria were appropriate for the specifics of the scenario and the tasks being carried out at the time. Temporality was a topic for education during the simulations, both in terms of figuring out how to increase the students' knowledge and as a stand-alone subject. Strong correlations between tasks, instruction, and technology were found.

During various phases of simulator-based training, Sellberg (2017) sought to investigate the possibilities and instructional challenges for transferring generic learning lessons to real-world scenarios. The research included both ethnographic fieldwork and video recordings of classroom practices from a marine navigation course. During scenarios and exercises, the nautical students worked in two-person teams, taking turns learning the many duties of the officer-of-the-watch and keeping an eye out while carrying out the commands of the bridge crew aboard a ship with cutting-edge equipment. The results highlighted the importance of pre-simulation evaluation and post-simulation assistance to improve learning toward a specialty. The results also showed how technology in the simulated setting gives teachers the option to continuously monitor, correct, and evaluate students' progress toward learning goals.

A thorough analysis of the usage of simulators in MET was undertaken by Sellberg (2016), and the focus was directed on bridge operations during navigation training. A global field of research combining three significant disciplines was revealed by the review's identification of 34 papers that appeared in a variety of scholarly periodicals. Human factors, education, and marine careers. The results demonstrated that, despite the clear advantages of using simulators for training and evaluation, it is unknown if teaching strategies can ensure accurate and reliable outcomes for simulator-based education.

4. RESEARCH GAP AND CONTRIBUTION

The main gap identified from previous literature is that most of prior studies did not use the SOFTES model to evaluate the benefits of training simulations. On the other hand, only one study has been mentioned to test the SOFTES model, which is (Shalaby and Hassan, 2019), where this study has evaluated SOFTES model but in another sector differ from the current study, which is nursing sector.

Accordingly, the current study has two contributions. First contribution is applying a study that aims to investigate the outcome of implementing structured SOFTES model as a post simulation debriefing strategy inside the sector of Maritime Training. Second contribution is applying a multiple factorial elements of SOFTES model (Student, Objectives, Facilitator, Time, Environment, and Skills competency) that allows reaching a wider understanding of this model and its importance.

5. RESEARCH METHODOLOGY

The research studied the impact of implementing the SOFTES model as a debriefing strategy after the practical experience of the ship handling course on marine trainees' outcomes. The flow of current methodology is applied as follows:

1. A quantitative self-administered questionnaire was used to collect the data.
2. The questionnaire was answered by one hundred marine trainees. Two groups, each group is fifty trainees, were the result of splitting. Group (1) called the control group received the questionnaire without taking a structured debriefing after finishing the simulation is called the control group. Group (2) called the experimental group trained on the SOFTES model after the simulation training.
3. SOFTES model was created to help the experimental group trainees self-analyze and self-evaluate after the training. The experimental group received an orientation training workshop to practice SOFTES model. Six terms represent the meaning of the term (SOFTES) which are Student, Objectives, Facilitator, Time, Environment, and Skills competency. The questionnaire included questions about each term. SOFTES model helped to increase trainees' self-

confidence and self-evaluation. So, it was expected SOFTES model helped to decrease trainee's anxiety and it was expected that there is a relationship between SOFTES model and skill competency.

4. The researcher used descriptive analysis for variables and comparing analysis using the T-test was used to study the effect of SOFTES model on the self-analysing and self-evaluation of the trainees after the simulation training.
5. The analysis was done by comparing the two groups using the T-test. For comparing the means of two experimental and control groups, a T-test was used. According to (Shalaby and Hassan, 2017).

Table 1 shows the questionnaire that was used to get the data for this research.

Table 1- The used questionnaire

Variable	*Statement*	*Reference*
Student	1- Encouraged me to consider my own ideas and emotions regarding a particular experience 2- Being sensitive to my advantages and limitations. 3- Being aware of my own emotions and sentiments so that I could deal with both myself and others. 4- Helped me to increase my confidence.	(Mahlanze and Sibiya, 2017)

Variable	*Statement*	*Reference*
Objective	1- Helped me understand and advance my comprehension of learning objectives 2- Increased my level of participation. 3- Improved my skill of reflection and thinking 4- Helped me develop my observational abilities 5- encouraged me to seek out more information in order to be prepared for key experiences and events in the future	(Mahlanze and Sibiya, 2017)
Facilitator	1- I had the chance to practice at the simulation 2- I had the chance to view high-fidelity simulators. 3- I am pleased with the instructor's performance and level of expertise during the simulation. 4- The instructor provided all facilities	(Agha et al., 2015)
Timing	1- The time for each step is suitable 2- There is some distribution wasted my time 3- can continue work as planned if I'm interrupted	(Agha et al., 2015)

Variable	*Statement*	*Reference*
Environment	1- The simulated environment was comfortable 2- I had a hard time treating the simulator as a real ship 3- A good method of learning is the simulator 4- A realistic experience was offered using the simulator 5- The subject was more interesting thanks to the simulator	(Agha et al., 2015)
Skills competency	1- I can link theory to the actual experience 2- Helped me increase my problem solving 3- Helped me increase my ability to make proactive decisions 4- I have the capacity to reinterpret situations and issues 5- I can learn from my mistakes and avoid them in future	(Mahlanze and Sibiya, 2017)

6. RESULTS AND FINDINGS

After running the data analysis, the experimental studies and then the results will be presented in this chapter.

6.1 Descriptive analysis

Table two presents the mean, standard deviation, and frequency for the trainees' age, gender, income, and marital status. The age is represented by (1) between 18 and 25 years, (2) between 26 and 40 years, and (3) bigger than 40 years. The gender is represented by (1) males, and (2) females.

The Income is represented by (1) for between 0 and 5000 EGP, (2) for between 5000 and 10000 EGP, (3) for between 10000 and 20000 EGP, and (4) for more than 20000 EGP. The marital status is represented by (1) single, (2) married, and (3) divorced. It was observed no big difference between trainees' means. So, the is no influential effect for these variables in the results.

Table 2- Descriptive analysis of trainees' profiles

Variable	*N*	*Mean*	*Std. Deviation*	*Frequency*			
				1	*2*	*3*	*4*
With SOFTES							
Age	50	1	.19795	48	2	0	-
Gender	50	1	.00000	50	0	-	-
Income	50	2	.00000	0	50	0	0
Marital status	50	1	.23990	47	3	0	-
Without SOFTES							
Age	50	1	.00000	50	0	0	0
Gender	50	1	.00000	50	0	-	-
Income	50	2	.00000	0	50	0	0
Marital status	50	1	.27405	47	3	0	-

The mean, standard deviation, and frequency for the research variables are shown in table 3. It was shown that the frequency was unstable and (2) is the most repeated rating for the control group, and (4) is the most repeated rating for the experimental group, also the values of means for variables (student, objective, facilitator, timing, environment, skill competency) for the control group are (1.86, 1.78, 1.86, 1.68, 1.52, 1.68) and the values of means for variables (student, objective, facilitator, timing, environment, skill competency) for the experimental group are (4.54, 3.88, 4.04, 3.74, 3.76, 3.74). It was observed the difference between means that show the impact of SOFTES model.

Table 3- Descriptive analysis of variables

Variable	*N*	*Mean*	*Std. Deviation*	*Frequency*				
				1	*2*	*3*	*4*	*5*
With SOFTES								
Student	50	4.5400	.50346	0	0	0	23	27
Objective	50	3.8800	.38545	0	0	7	42	1
Facilitator	50	4.0400	.40204	0	0	3	42	5
Timing	50	3.7400	.44309	0	0	13	37	0
Environment	50	3.7600	.59109	1	0	10	38	1
Skill competency	50	3.7400	.59966	1	0	11	38	1
Without SOFTES								
Student	50	1.8600	.35051	7	43	0	0	0
Objective	50	1.7800	.46467	12	37	1	0	0
Facilitator	50	1.8600	.35051	7	43	0	0	0
Timing	50	1.6800	.47121	16	34	0	0	0
Environment	50	1.5200	.50467	24	26	0	0	0
Skill competency	50	1.6800	.47121	16	34	0	0	0

6.2 Validity and reliability

Validity is known as the range that measures the meaning or concept accurately in a quantitative study. For example, a poll intended to study depression but instead measuring anxiety, would not be seen as valid. On the other hand, reliability refers to the accuracy and consistency of the measures (Heale and Twycross, 2015).

If a test has high validity, it was concluded objectives have a high connection with items. On the opposite, it was concluded objectives have a low connection with items if a test has low validity. The validity was measured by two main factors (Average Variance Extracted (AVE), and Factor Loading (FL)). AVE should be greater than 0.5. The FL of each item should be greater than 0.4.

The consistency of measures was known as reliability. The test should be better if having high reliability. The value of Cronbach's Alpha is used to measure the reliability. The value of Cronbach's Alpha is between 0 and 1. The reliability is increased when Cronbach's Alpha increases. If Cronbach's Alpha exceeds 0.7, it refers to being reliable enough. The results are shown in Table 4.

Table 4- Validity and Reliability for each variable

Variable	*Statement*	*Factor loading*	*AVE*	*Cronbach's Alpha*
Student	Encouraged me to consider my own ideas and emotions regarding a particular experience	0.871	89.429	0.960
	Being sensitive to my advantages and limitations	0.895		
	Being aware of my own emotions and sentiments so that I could deal with both myself and others.	0.896		
	Helped me to increase my confidence.	0.916		
Objective	Helped me understand and advance my comprehension of learning objectives	0.867	86.064	0.959
	Increased my level of participation.	0.825		
	Improved my skill of reflection and thinking	0.855		
	Helped me develop my observational abilities	0.876		

Variable	*Statement*	*Factor loading*	*AVE*	*Cronbach's Alpha*
	encouraged me to seek out more information in order to be prepared for key experiences and events in the future	0.881		
Facilitator	I had the chance to practice at the simulation	0.838	85.177	0.942
	I had the chance to view high-fidelity simulators.	0.871		
	I am pleased with the instructor's performance and level of expertise during the simulation.	0.847		
	The instructor provided all facilities	0.851		
Timing	The time for each step is suitable	0.845	85.399	0.914
	There is some distribution wasted my time	0.858		
	can continue work as planned if I'm interrupted	0.859		
Environment	The simulated environment was comfortable	0.844	85.846	0.959
	I had a hard time treating the simulator as a real ship	0.857		
	A good method of learning is the simulator	0.849		
	A realistic experience was offered using the simulator	0.871		
	The subject was more interesting thanks to the simulator	0.872		
	I can link theory to the actual experience	0.840	85.126	0.956

Variable	*Statement*	*Factor loading*	*AVE*	*Cronbach's Alpha*
Skill Competency	Helped me increase my problem solving	0.819		
	Helped me increase my ability to make proactive decisions	0.859		
	I have the capacity to reinterpret situations and issues	0.869		
	I can learn from my mistakes and avoid them in future	0.869		

6.3 Comparing two groups

The difference between the two groups was shown in Table 5. It was observed that the mean for the group that was trained with SOFTES is greater than the mean for the group that was trained without SOFTES in each variable. Also, the significance is smaller than 0.001. This means the SOFTES model has a positive impact on the behaviors of groups.

Table 5- Comparing between two groups in mean

Variable	*SOFTES*	*N*	*Mean*	*Std. Deviation*
Student	With SOFTES	50	4.5400	.50346
	Without SOFTES	50	1.8600	.35051
Objective	With SOFTES	50	3.8800	.38545
	Without SOFTES	50	1.7800	.46467
Facilitator	With SOFTES	50	4.0400	.40204
	Without SOFTES	50	1.8600	.35051
Timing	With SOFTES	50	3.7400	.44309
	Without SOFTES	50	1.6800	.47121
Environment	With SOFTES	50	3.7600	.59109
	Without SOFTES	50	1.5200	.50467
Skill competency	With SOFTES	50	3.7400	.59966
	Without SOFTES	50	1.6800	.47121

7. RESEARCH DISCUSSION

This section discusses if the objectives of the research are achieved or not. The researcher used a questionnaire to collect the data, this questionnaire was answered by one hundred marine trainees. One hundred marine trainees were split into two groups (the experimental group, the control group). The experimental group was trained on SOFTES model besides the normal training. In opposite, the control group took the normal training only.

SOFTES model was established to guide the self-reflection and self-analysis of the trainees. The result showed that there is a positive and significant impact of the SOFTES model on the marine trainees, as a result of (Shalaby and Hassan, 2017) showed also the same impact. Also, the result showed that SOFTES model helps in reducing the trainees' anxiety level, increases their ability to analyze themselves, and increases their self-confidence.

8. RESEARCH CONCLUSIONS

This research is done on one hundred trainees divided into two groups. This research suggested an initial hypothesis which is a new framework called SOFTES model used in training has a significant relationship with the trainees' behaviors. This research results showed that SOFTES model has a positive relationship on trainees' behaviors. SOFTES model was associated with decreasing the anxiety of trainees and helped in increasing self-confidence. The results appeared in the difference between the answers of the two groups on the questionnaire.

9. RESEARCH RECOMMENDATIONS

Some recommendations that may benefit the decision maker is provided in this section;

1- Implementing SOFTES model in every training in all sectors, because SOFTES model increased self-analysis and self-evaluation which helps in increasing self-confidence and reflects improving the performance and outcome of the organizations.

2- Facilitators should be trained on SOFTES MODEL to know its importance and t know how to train the student to gain more ability in self-analysis.

3- Continuously, should be making a questionnaire to the trainees and taking their suggestions to improve the simulations and the implementation of SOFTES model in how it helped them in improving self-analysis.

Other recommendations are also mentioned, which could help in the improvement of SOFTES model, are represented as follows:

1. Instructors and trainers should give a debriefing about SOFTES model during the training simulators in order to make trainees more aware about this model and by that they will be able to give wiser opinion and evaluations.
2. Apply SOFTES model in different types of simulations, in which allows different ways of understanding to this model and its effectiveness on different simulations.

3. It is recommended to make more studies on SOFTES model and collect both quantitative and qualitative data from experts to evaluate this model and concluded new effective ways of developing this model.

10. RESEARCH LIMITATIONS

Every scientific study has a limitation that could prevent the conclusions from being applied generally. The limitation faced by this research is the rareness of the previous research that discussed the SOFTES model and its impact on self-analysis and self-evaluation. The researcher suggested for future researcher focus on implementing SOFTES model and comparing the trainees' self-analysis and self-evaluation before implementing SOFTES model and after. Another suggestion to decision-makers is to implement and train all students on the SOFTES model over all the sectors because the result showed its impact on self-analysis and increasing self-confidence. Another limitation is the smallness of the sample size, the researcher suggests to future researchers take a bigger sample size, which helps in getting more accurate results.

7. ACKNOWLEDGMENTS

To complete this work, I am greatly thankful from the core of my heart to maritime officers and experts staff inside a simulation training in the Arab Academy for Science, Technology and Maritime Transport (AASTMT), who had helped me to collect valuable information that support my research.

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Future-Proof Infrastructure for improving Port-City Integration

AN EMPIRICAL RESEARCH ON CONNECTING PORT AND CITY INFRASTRUCTURE AND ITS IMPLICATIONS FOR THE ECONOMY – CASE STUDY: BLACK SEA PORTS

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Keywords: Black Sea ports, Port, City, Infrastructure, Case study, Empirical research

1. **ABSTRACT:** The connection between port and city infrastructure is a hot topic in the global economic context, in general, and in European and Asian economic situations, particularly. In the last year, in the context of the Russian invasion of Ukraine, the Black Sea region and its ports have become a topic of interest to the European Union. The paper aims to briefly present and better understand the economic situation of the Black Sea region by presenting the connection between its ports and cities' infrastructure. The methodology approach was based on a qualitative research method. The authors focused on the description of the characteristics of the ports, as well as on the presentation of the turnover generated, by the country of origin. The paper contributes to the deepening of the theoretical framework to better understand the port and city infrastructure and its implication for the economy.

2. INTRODUCTION

In the nowadays international context, the theme of connecting port and city infrastructure is a topic of major interest. Therefore, port cities should consider the importance of competitive development (Gurzhiy, Kalyazina, Maydanova, & Marchenko, 2021). However, there are positive and negative factors that affect the connectivity between the port and the city. Thus, the positive benefits are in the economic area (Gurzhiy, Kalyazina, Maydanova, & Marchenko, 2021), but the negative consequences are environmental impact, traffic loads on infrastructure, and the needs of the port for new space (Notteboom & Rodrigue, 2008).

Taking into account the growing interdependence of the world's economies, the importance of seaports in the global supply chain raises more and more (Munim & Schramm, 2018). Consequently, the development of seaports is required by increasing trade and demand for sea transport (Bogusz & Artur, 2016).

The Black Sea area is a topic of interest in Europe, in general, and, to the European Union, particularly. This region is of importance to the European Union for a variety of reasons, from economics and security to energy and transportation (Coffey, 2020). Thus, the economic activity in the region is influenced by the major European ports – Port of Constanța (Romania), Samsun Port

(Turkey), Port of Odessa (Ukraine), Batumi Seaport (Georgia), and Port Varna (Bulgaria) (Babali, 2022).

In the shipping industry, port infrastructure refers to port competitiveness (Martinez & Feo, 2016), port connectivity (Acosta, Coronado, & Mar Cerban, 2007; De Langen, 2007), port location (Wiegmans, Hoest, & Notteboom, 2008), and port charges (Tongzon, Chang, & Lee, 2009).

The paper consists of four major sections. Following this brief introduction that contains a review of the literature, the third section is dedicated to the research methodology, while the fourth presents the principal results and discussion. The paper ends with conclusions and suggestions for future research in this area.

3. RESEARCH METHODOLOGY

In order to achieve the research objective set up in the paper, the authors based their research methodology on a quantitative research method (Figure 1). For the literature review, the authors used electronic databases containing various scientific articles, books, web articles, and academic courses from the field of ports and cities infrastructure, in general, and regarding the situation through the Black Sea region, particularly. The documents were found in prestigious databases such as Google Scholar, Emerald Insight, Scopus, Web of Science, and Science Direct.

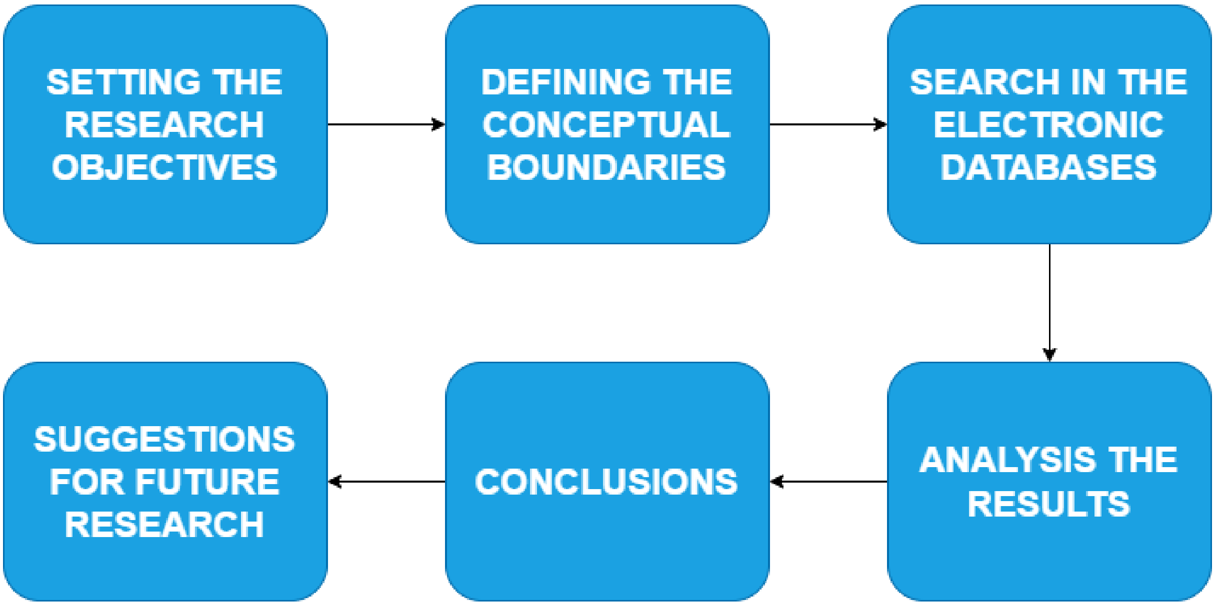

Figure 1: Phases of the research methodology

The information was synthesized highlighting the aspects regarding the topic of ports and city infrastructure. Finally, the authors concluded the paper, pointed out the conclusions, followed by the performed analysis, and provided suggestions for future research.

4. RESULTS AND DISCUSSION

In terms of geographical location, the Black Sea region enjoys a favorable position, surrounded by eastern European countries such as Romania, Bulgaria, Georgia, Moldova, Turkey, Russia, and Ukraine (Dasgupta, 2022). The major Black Sea ports are presented in Table 1.

Table 1. The major Black Sea ports

Name	*City*	*Country*
Port of Constanța	Constanța	Romania
Port of Odessa	Odessa	Ukraine
Port of Novorossiysk	Novorossiysk	Russia
Port of Varna	Varna	Bulgaria
Feodosia Port	Feodosia	disputed between Ukraine and Russia
Port of Hopa	Hopa	Turkey
Samsun Port	Samsun	Turkey
Batumi Port	Batumi	Georgia

In terms of economic development, is important to show the Black Sea region turnover in 2021 in comparison with 2020 by TEU (twenty-foot equivalent unit), laden containers to see to what extent these port-cities take advantage of the opportunities that this status generates. So, in the following table it is presented the data (Table 2).

Table 2. The Black Sea region turnover in 2021 and 2020 by TEU, laden containers

Country	*2021*	*2020*	*Growth*
Ukraine	829,725	819,958	1,19 %
Russia	660,581	589,961	11,97 %
Romania	481,210	469,664	2,46%
Georgia	247,415	283,404	-12,7 %
Bulgaria	206,742	201,346	2,68%
TOTAL	2,425,673	2,364,333	2,59%

Source: (Container News, 2022)

The authors of this paper presented some of the characteristics of each of these eight ports and the implications regarding the port and city infrastructure. Comments based on these aspects will be made in the following subsections.

4.1 Port of Constanța (Romania)

The port of Constanța is located in the southeastern part of Romania and it is the country's largest port (Babali, 2022). The port is a public-private seaport owned by the Romanian state through the Ministry of Transportation (Olteanu, Drăgan, & Stinga, 2022). Moreover, this is the largest Black Sea port and it is connected with all major ports of Eastern and Central European nations (Dasgupta, 2022) through Corridor IV (rail and road), Corridor VII – Danube (inland waterway), to which it is linked by the Danube-Black Sea Canal, and Corridor IX (road), which passes through Bucharest (International Port Community Systems Association, 2023). The most important types of vessels calling at Constanța are General Cargo (25%), Bulk Carrier (16%), Oil/Chemical Tanker (9%), Inland, Motor Freighter (8%), Container Ship (5%) (MarineTraffic, 2023).

The port is split into two sections known as the North and the South port (Dasgupta, 2022). Nowadays, this port is of very interest to Romania and to European Union, because in 2022, even though the port is facing some capacity issues, it is also beginning to ship Ukraine's grain exports (Babali, 2022).

Concerning the port and city infrastructure, the railway infrastructure of this port will be modernized soon through a EUR 1 billion investment project financed by the European Union (Dumitrescu, 2022). Furthermore, the city of Constanța has a very important social, economic, political, and cultural role in Romania (Barbu, Deselnicu, & Militaru, 2022), is also one of the most famous tourist cities on the Romanian Black Sea coast (Moraru, Duhnea, Barbulescu, Juganaru, & Juganaru, 2021). Moreover, various projects are currently being performed in the port to modernize the infrastructure, such as the following (Dumitrescu, 2022):

- placing equipment;
- modernizing the fleet of technical ships for waste collection from ships;
- balancing the accessibility of rural-urban areas;
- carrying out infrastructure works for the development of specialized terminals.

4.2 Port of Odessa (Ukraine)

The port of Odessa is one of the most important ports in this region, spans 141 hectares and comprises 54 wharves (Dasgupta, 2022). It is the largest port in Ukraine, located near the city of Odessa, about 150 kilometres from the Romanian border (Babali, 2022). The port was opened in 1974 and is owned by the Ukrainian Sea Ports Authority (Joshi, 2022). The total annual traffic capacity is 40 million tonnes - 15 million tonnes of dry bulk and 25 million tonnes of liquid bulk (SeaRates, 2023).

Considering the port and city infrastructure, it is necessary to mention that Odessa is an industrial city, famous for its chemical industries producing paints, natural and artificial dyes, and fertilizers (Joshi, 2022). Moreover, regarding the connection with tourism, the port city has many serene beaches such as the Arcadia which is Ukraine's most popular beach, close to the city centre (Joshi, 2022).

The port of Odessa is one of the most important departure points for Ukrainian cereals to international markets, which provides Ukraine with substantial revenues – in 2021, Ukraine was the fourth largest grain exporter in the world (Costea, 2022).

4.3 Port of Novorossiysk (Russia)

Situated on the northeastern Black Sea coast, Port Novorossiysk is the main port of Russia, which handled 142 million tonnes of cargo in 2020 (Dasgupta, 2022). This port is specialized in handling general cargo, bulk, containers, foodstuffs, timber, crude oil and oil products (Eisa shipping agencies, 2022).

In September 2022, following the signing of a contract the Eastern Economic Forum. Delo Group, Gazprombank and the Bamtonnelstroy-Most Group (BTS-MOST), The Port of Novorossiysk is to have improved road connections (PortsEurope, 2022).

Some of the main projects regarding the connection between the port and city infrastructure are the following (ROSMORPORT, 2023):

- project for reconstruction of berths No. 34 and No. 34a of the Cabotage Bulwark designed for serving passenger's vessels;
- project for reconstruction of the Novorossiysk seaport water area;
- project to implement the second stage of modernization of the differential global navigation satellite system in the Black Sea.

4.4 Port of Varna (Bulgaria)

The port of Varna is an important Black Sea port, situated on the western coast of the sea (Dasgupta, 2022). It consists of two main ports: Varna East and Varna West as well as some smaller ports: Balchik, Lesport, Ferry complex, Varna Power Plant (Eisa shipping agencies, 2023). Moreover, considering its proximity to the Bosporus, and therefore high seas, Port Varna is in a strategic position, being more than a Black Sea facility (Babali, 2022).

Considering the port and city infrastructure, the port of Varna provides easy and convenient access to the Bulgarian road network. Furthermore, all berths of the Port of Varna have access to Bulgaria's rail network, and Varna Airport is the second largest international airport of Bulgaria situated 10 km away from the city centre (Port of Varna, 2023).

4.5 Feodosia Port (disputed between Ukraine and Russia)

Feodosia port of Varna is situated in the Crimea region, in the Gulf of Theodosia adjacent to the Black Sea (Dasgupta, 2022). The current status of this port is disputed between Ukraine and Russia (UkraineTrek, 2023). This port mainly handles oil and petroleum goods and derivatives (Dasgupta, 2022).

Taking into consideration the Russian invasion of Ukraine (Financial Times, 2023) and the annexation of Crimea by the Russian Federation (Britannica, 2023), it's hard to present the correlation between port and city infrastructure and its perspectives.

4.6 Port of Hopa (Turkey)

The port of Hopa became operational in 1972 and it is at the eastern border of the Eastern Black Sea (Dasgupta, 2022). The port was privatized in 1997 transferring the operating rights for a period, of 30 years, to Park Denizcilik Ve Hopa Liman İşletmeleri A.Ş. by Türkiye Denizcilik İşletmeleri A.Ş. (Hopaport, 2023).

With ongoing investments in the field, these are the major correlations between port and city infrastructure that provide opportunities for transportation to both the domestic market and other countries specified by the buyer companies (Hopaport, 2023).

4.7 Samsun Port (Turkey)

The Samsun Port is Turkey's greatest access point to the Black Sea, linking Turkey to all five other countries in the Black Sea region (Babali, 2022). It is frequented by large bulk carriers carrying heavy bulk and general cargo, fishing boats, oil and chemical tankers and ro-ro ships (Dasgupta, 2022). The most important types of vessels regularly calling at Samsun are General Cargo (58%), Fishing (10%), Bulk Carrier (9%), Ro-Ro Cargo (5%), Oil/Chemical Tanker (4%) (Samsun Port, 2023). Samsun Port is a multi-purpose port which serves any kind of ship and freight. Most of the freight at the port is for international business (Yilmaz, 2006).

Some of the main facilities regarding the connection between the port and city infrastructure are the following (Invest Samsun, 2023):

- logistic facilities;
- industrial infrastructure;
- human resources.

4.8 Batumi Port (Georgia)

The Batumi Port is one of the oldest ports, with a history that dates back to Roman times (Babali, 2022). It is an important Georgia's port and it is situated on the southeastern coast of the Black Sea (Dasgupta, 2022). It is specialized in purifying oil, and fuel, but it also handles shipments of metals, grains, cement, fertilizers, corn, wood, construction equipment and sugar (Dasgupta, 2022). Moreover, the port is connected to the nearby republic of Azerbaijan through the Baku-Tbilisi-Kars railway, thus creating an on-land logistical corridor between the Black Sea and the Caspian Sea (Babali, 2022).

5. CONCLUSIONS

The paper contributes to the deepening of the theoretical framework to better understand the port and city infrastructure and its implication for the economy. It also shows that the Black Sea region is very important in nowadays international context. Moreover, the presentation of the Black Sea ports' characteristics and their implication for the economy can be considered an added value.

There is a need for future research related to ports and city infrastructure in Europe and on other continents. Moreover, another field of interest should be the implication of the COVID-19 pandemic on the infrastructure of ports and cities.

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FUTURE PROOF INFRASTRUCTURE FOR PORT-CITY: CASE STUDY FOR THE SUSTAINABILITY OF SUEZ CANAL ENTRANCE GROINS AGAINST FUTURE EXTREME WAVE CONDITIONS

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ABSTRACT: In line with market needs, ports should adopt green-port policies that integrate social, economic, and environmental factors. Several coastal international organizations are spreading awareness of maritime market needs for Sustainability Development Goals (SDGs). Resilience infrastructure of cruise tourism ports is one of the key cornerstones for future-proof port-city infrastructure. In port-city coastal projects, each port is a city. Ports integrate markets and provide services, creating economic benefits. Port-cities are economically important marine hubs, they connect the local and global.

The article aims to study the future proof infrastructure for port-city using a case study for the sustainability of entrance groins of Suez Canal against future extreme wave conditions. As sustainable development boosts port performance. Coastal planning prioritizes sustainability as the rapid growth of the global market has caused a socioeconomic development-environmental asset mismatch, creating major social, economic, and environmental dangers. Sustainable development meets requirements without compromising Earth's capacity to meet future needs. SDGs are the best strategy to decrease port damage to cities. Climate change affects port sustainability. Climate change-induced sea level rise and powerful waves may threaten breakwaters and groins.

To fulfil market needs, ports require green-port policies that incorporate social, economic, and environmental aspects.

The numerical model integrates World Ports Sustainability Program (WPSP) infrastructure and digital components. DHI MIKE21 SW numerical modelling is used a digitalized tool to validate the infrastructure of Suez Canal entry groin sustainability against future extreme wave conditions.

The results for the spectral waves height values for different return periods of different directions till 100 years return period conditions show that the values are less than 0.30m for most of Port Said Ports. However, H_s value at the entrance of West Port said Port reaches 0.76m, which needs further sustainable infrastructure planning.

Keywords: Sustainability Development Goals, Sustainable Infrastructure, Suez Canal, Spectral Wave Modelling, DHI MIKE21 SW FM

1. INTRODUCTION

Ports should establish green-port policies interconnected via social, economic, and environmental aspects in accordance with market demands. Several coastal international organizations and projects are increasing awareness of the coastal market needs for meeting the Sustainable Development Goals

(SDGs). Resilience infrastructure of the Cruise touristic ports is one of the main pillars to achieve the sustainability for future-proof Infrastructure for the port-Cities. Tourism growth along the Mediterranean coast has resulted in tremendous urban development, notably along the coastlines of Europe. Because of the environmental implications, the present port infrastructure should be expanded and upgraded in the future.

Nebot (2017) processed prospective port system improvement proposals based on international port literature. These concepts emerged from several fields, but they have now been brought together to provide a holistic understanding of the discussion. These are integrated port management, sustainable resilience infrastructures for ports, port regionalization, connectedness to the landscape and urban regions, and socially integrated ports. In port-city coastal projects, each port has its own city, as is customary in coastal communities. Ports function as economic market integration and service agglomeration while also generating economic advantages. Cities provide the resources and infrastructure necessary for cities to build their ports (Cong et al., 2020).

Port-cities are economically significant institutions that provide a considerable source of maritime activity. They serve as a bridge between both the local and global surroundings. The beneficial spillover effects of the port hinterland tend to be focused on port-cities due to the rapid speed of economic globalization and the continual growth of ports' hinterlands. However, negative consequences of port-city expansion, such as pollution, arise. As a result, sustainable development is a critical factor in increasing port performance (Kong and Liu, 2021).

The World Commission on Environment recommended environmental sustainability in 1987 as a way to establish a community that fulfils our present needs while simultaneously conserving future generations' ability to do so. The United Nations Sustainable Development Summit formally endorsed 17 UN SDGs on September 25, 2015. Sustainable development has emerged as the major objective of coastal planning. The fast expansion of the international market has created an imbalance among socioeconomic development and environmental assets, posing serious social, economic, and environmental threats. Sustainable development was presented as a way of development that satisfies demands without endangering earth capability to satisfy future human needs. Achieving UN SDGs is the most effective way to reduce the harmful impacts of ports on cities (IAPH-WPSP, 2022).

Port adaptation and sustainability depend on climate change. Sea level rise and strong wave characteristics due to climate change might jeopardize breakwaters and groins (Takagi et al., 2011).

DHI MIKE21 SW numerical modelling is used to validate the sustainability of Suez Canal entrance groins during severe wave conditions. The numerical model applies WPSP infrastructure and digitization components to meet market demands, ports need green-port policies that integrate social, economic, and environmental factors (IAPH-WPSP, 2022).

The expansion of different coastal activity and the necessity for world market competition force ports to explore all opportunities for efficiency and reduced cost (Pavlic et al., 2014). Ports can reduce their environmental footprint by applying innovative sustainable infrastructure solutions (Twrdy and Zanne, 2020). For innovated ports, the environment dimension should be prioritized over the social and economic dimensions to attain sustainability (Sengar et al., 2018).

Climate change impact, as main dimension of the environment dimensions for the sustainability, is a critical component to port adaptation and sustainability. Climate change is expected to lead to increases in both sea level and extreme wave characteristics, which could threaten the stability of breakwaters and the groins (Takagi et al., 2011). Ports need to develop green-port policies interlinked via social, economic, and environmental dimensions to strengthen port processes as ports market requirements (Schipper et al., 2017). There are several coastal international organizations and programs which are raising the awareness of the coastal market requirements of achieving UN SDGs, such as World Ports Sustainability Program (WPSP). The International Association of Ports and Harbors (IAPH) developed the WPSP in 2017 to help ports in implementing the 17 UN SDG. The initiative aims to improve and coordinate the future sustainability efforts of ports throughout the globe and to develop international collaboration with the international partners (IAPH-WPSP, 2022).

To study the sustainability of the ports infrastructure and to achieve a future proof infrastructure, ports infrastructure should be validated for the capability to stand against the expected extreme weather events with longer life time, along with the required rehabilitation works if required. Coastal planning prioritizes sustainability as the rapid growth of the global market has caused a socioeconomic development-environmental asset mismatch, creating major social, economic, and environmental dangers. Sustainable development meets requirements without compromising Earth's capacity to meet future needs. SDGs are the best strategy to decrease port damage to cities as climate change affects port sustainability.

Lowe (2005) discovered that projections of future severe sea levels are uncertain, but that changes in atmospheric storminess will result in changes in the height of water levels measured relative to the current storm wave. This could lead to more extreme coastal waves. Additionally, Grabemann (2008) found that towards the end of the twenty first century, global warming may cause extreme wave heights to rise by roughly 0.3 m. This also suggests that climate change will lead to more extreme coastal waves. However, when comparing the years 1961-1990 to the years 2071-2100, Winter (2012) determined that the circumstances of the annual maximum waves in front of the European coast were not expected to alter greatly due to climate change. For high-frequency severe wave occurrences, Morim (2021) revealed that in the Representative Concentration Pathway 8.5 (RCP8.5) high-emission scenario, changes of 50%-100% are predicted, which is roughly twice the estimated changes for RCP4.5 scenario. According to Kaiser (2020) DHI MIKE21 Spectral waves with flexible meshes (DHI MIKE21 SW FM) should be used to get two-dimensional wave heights for Port Said and Suez Canal region based on wave bottom interactions and wave structure interactions.

2. METHODOLOGY

2.1 Introduction

One of the main challenges for port development, such as Port Said Ports, is minimizing long-term uncertainty connected with infrastructure lifespan, such as breakwater lifetime, and substantial environmental consequences. The purpose of this article is to provide a numerical model simulation for evaluating the sustainability performance of the Suez Canal Entrance Groins. In order to analyses and understand future sustainable port-city development plans, this model evaluate a main key performance indicator (KPIs) against future forecasted severe wave conditions.

To study the sustainability of the entrance groins of Suez Canal as a market requirement for Achieving SDGs, DHI MIKE21 SW FM numerical modelling is constructed as shown in Figure 1) to ensure the efficiency of the entrance groins against the extreme wave conditions as a numerical validation analysis.

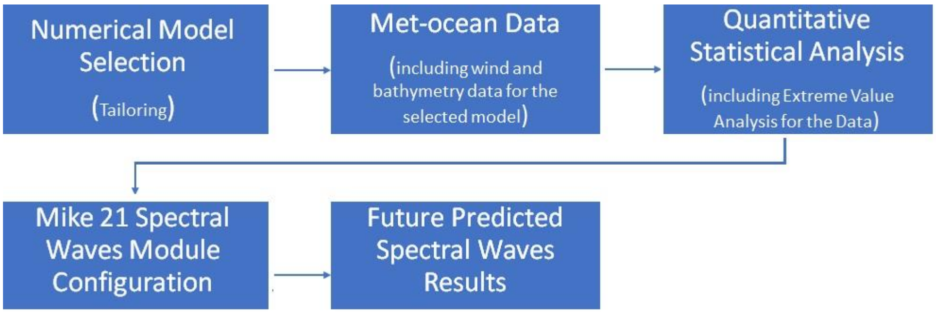

Figure 1: Flow Chart for DHI MIKE21 SW FM Numerical Modelling Generation

2.2 Numerical model selection

For the evaluation of conditions for waves in nearshore or coastal zones that typically requires the transformation of offshore wave statistics. The parametric model that is decoupled in the direction of the wave is recommended for the model. The formulation of directionally decoupled is a formula that can be utilized to generate small-scale wave transportation of waves to ports or shorelines, with a spatial scale can be as large as fifty kilometers. The spectral model is typically employed to predict waves simultaneously as well as analysis on a larger as well as local scales. For the region-scale aspect of the computational domain, it is necessary to have a low spatial and temporal resolution is employed. The full spectrum equation can be applied at various dimensions. This kind of formula is commonly used to forecast waves, and then analyses them using an unstructured mesh. The waters in the shallow areas around the coast should have a high-resolution border as well as depth. Regional modeling employs a small resolution spatial resolution (DHI, 2017).

2.3 Met-ocean data

The quantitative Met-ocean data for the point selected, as shown in Figure 2), was extracted using a multiyear-wave hindcast model that was derived from CMEMS database till the year of 2020, followed by a quantitative Met-Ocean data extracted from the global ocean analysis and prediction system with daily analyses for ocean surface waves and 3-hourly instantaneous fields till the year of 2022 (Copernicus Marine Service, 2022).

Figure 2: Quantitative Met-ocean Data for the Selected Point Location

Sets of preliminary experiments were performed to assess the influence of the reliability of the wave hindcast dataset. These tests for the Worldwide CMEMS dataset allow for a scatter index of less than 10% worldwide. The results show that CMEMS database has variations of H_s values reach -0.12 m on a regional scale of the Mediterranean Sea by using density of comparison data over 1120000 readings from CMEMS's satellite altimeters values and buoy readings (Copernicus Marine Service, 2020). Figure 3 shows comparison between scatter index of H_s for CMEMS and ERA5 results.

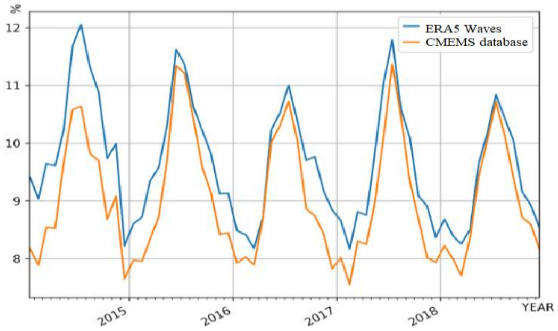

Figure 3: Comparison between shows time series of scatter index of Hs for CMEMS and ERA5 results

2.4 Quantitative statistical analysis

Parametric frequency analysis is utilized to study extreme wave characteristics instances using DHI Mike Zero, with using a threshold value of 0.01m to simulate the predicted significant wave height (H_s) based on the historical dataset of the met-ocean data. Theoretical probability distribution that is fitted into the extreme value series that is observed is used to create the model for extreme values (DHI, 2017). Statistical analysis methods are used to obtain extreme wave characteristics, as shown in Table 1.

Table 1. Statistical Analysis Criteria

Model duration	Partial duration series (PDS)
Probability distribution of the data	Distribution of Weibull
Probability plot correlation for the model	The probability plot correlation coefficient (PPCC)
Uncertainty calculation for the model	Monte Carlo simulation

Figure 4) illustrates the wave rose for different directions, and Figure 5) illustrates the frequency and probability plots for each direction.

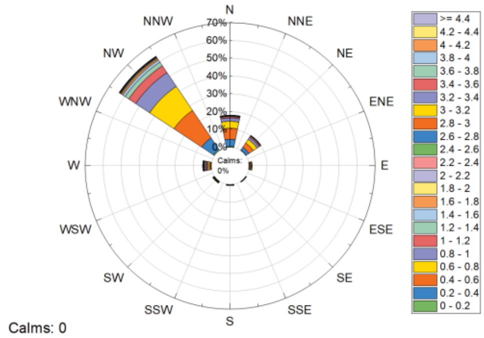

Figure 4: Wave Rose for Different Directions in front of Suez Canal, Port Said

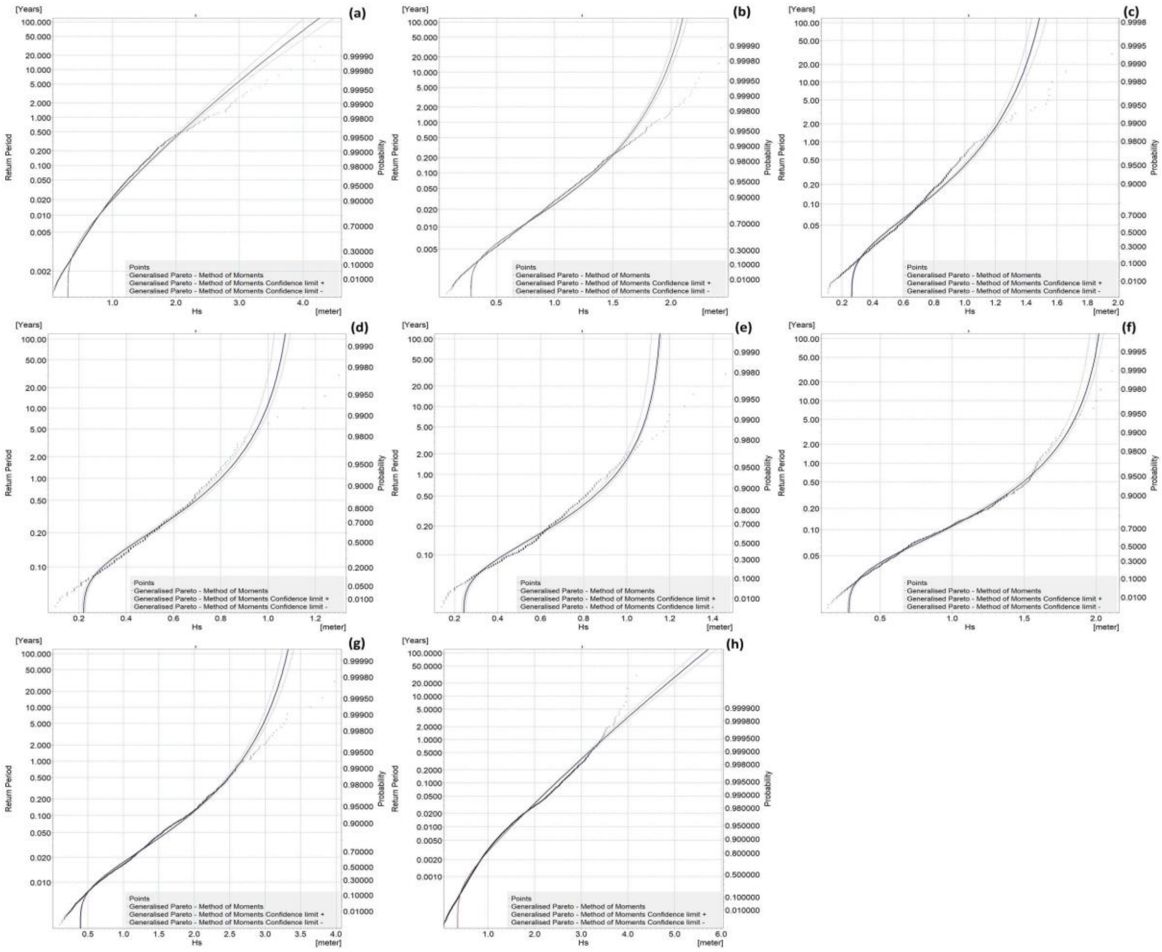

Figure 5: Analyzed Hs Values for Different Direction and Various Return Periods of (a) 0° (b) 45° (c) 90° (d) 135° (e) 180° (f) 225° (g) 270° (h) 315°

2.5 Model bathymetry and mesh

It is essential to give MIKE 21 SW FM with adequate mesh and bathymetry for appropriate results. Mesh is generated to have an appropriate resolution for bathymetry, wind fields, and other relevant factors. The primary purpose of modelling is to specify the depth of water inside the region of the model. The mesh file, including bathymetry, is generated via MIKE Zero Meshing Generator. It is a piece of software that facilitates the construction and manipulation of unstructured meshes. The mesh file is an ASCII file that contains bathymetry and geographic location information for each piece in the mesh (DHI, 2017). Bathymetry data from GEBCO is used to construct the bathymetry. MIKE Zero Mesh Generator is employed to process and build of meshes that are not structured. GEBCO's global terrain model that includes land and oceans and provides elevation data in meters (GEBCO Bathymetric Compilation Group, 2022). Figure 6) illustrates the generated numerical mesh for entrance groins of Suez Canal.

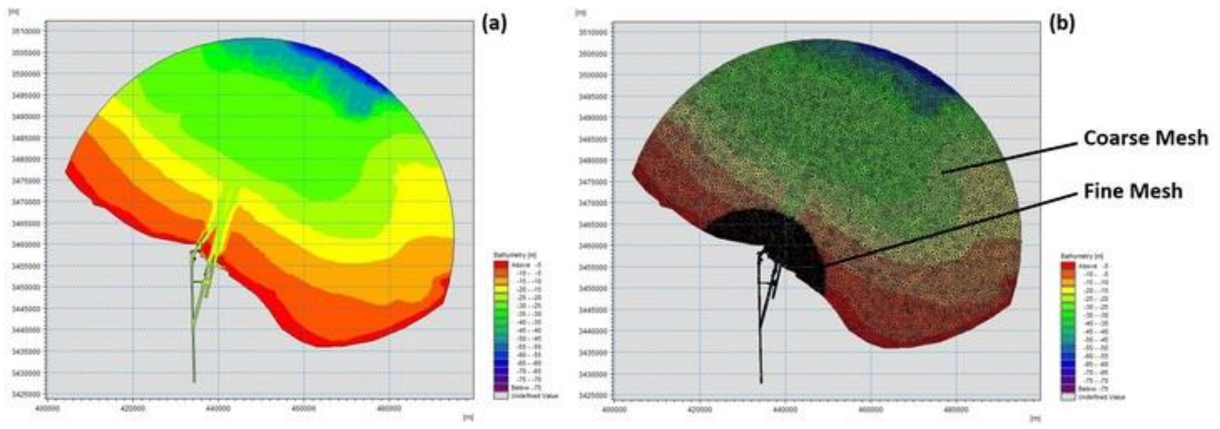

Figure 6: Numerical Mesh for Entrance Groins of Suez Canal (a) Mesh Bathymetry for the Model (b) Fine and Coarse Meshes for the Model

2.6 Model configuration and validation

In order to ensure the model validation, the model configuration is generated in accordance with the guidelines of MIKE21 SW FM by the Danish Hydraulic Institute of spectral wave modeling (DHI, 2017). The model allows wave generation in accordance with extreme wave characteristics of 8 directions for 5 different return periods of 5, 10, 20, 50 and 100 years return periods. Manning number value is considered 32 $m^{1/3}/s$, which is a factor used for future model calibration. MIKE21 SW FM model is built in accordance with the model criteria shown in Table 2.

Table 2. Statistical Analysis Criteria

Model Runs	40 runs of 8 directions in accordance with 5 different return periods of 5, 10, 20, 50 and 100 years Return Period
Model Type	Spectral Wave Flexible Mesh Model with Critical CFL equals 0.95
Wave Breaking	Wave Breaking with specific gamma of 0.8
Bottom Friction	Model of Nikuradse Roughness kn = 0.04
Bed Resistance	Manning Number equals to 32 $m^{1/3}/s$
Initial Conditions	Spectral JONSWAP fetch Growth Generation with Maximum fetch length of 10000 m

3. RESULTS AND RECOMMENDATIONS

Since the entrance groins of Suez Canal are approximately aligned with 30° to North, the related spectral waves height values for different return periods of directions 315°, 0° and 45° are the dominate H_s values for the prediction analysis. Figure 7) illustrates H_s values at the Suez Canal zone for 45° direction for different return period simulations. Figure 8) illustrates H_s values at the Suez Canal Entrance channel line for different direction and various return periods simulations. The results for the spectral waves height values for different return periods of different directions till 100 years return period conditions show that the values are less than 0.30m for Port said Touristic Port, Port said Shipyard, Sherif Basin, West Port said Port and East Port said Port. However, H_s value at the entrance of Port said Military Base reaches 0.76m, as shown in Table 3.

The results shows that the H_s values shall not be safe for maneuvering towards the navigation channel as the results are higher than 3.0 m for Suez Canal prevailing wave direction (PWD) of 315°.

The model is calibrated based on Hs values of the SW FM model results against Mediterranean-SW-WRF model prepared by DHI, from 1979 till 2011 as shown in Figure 9.

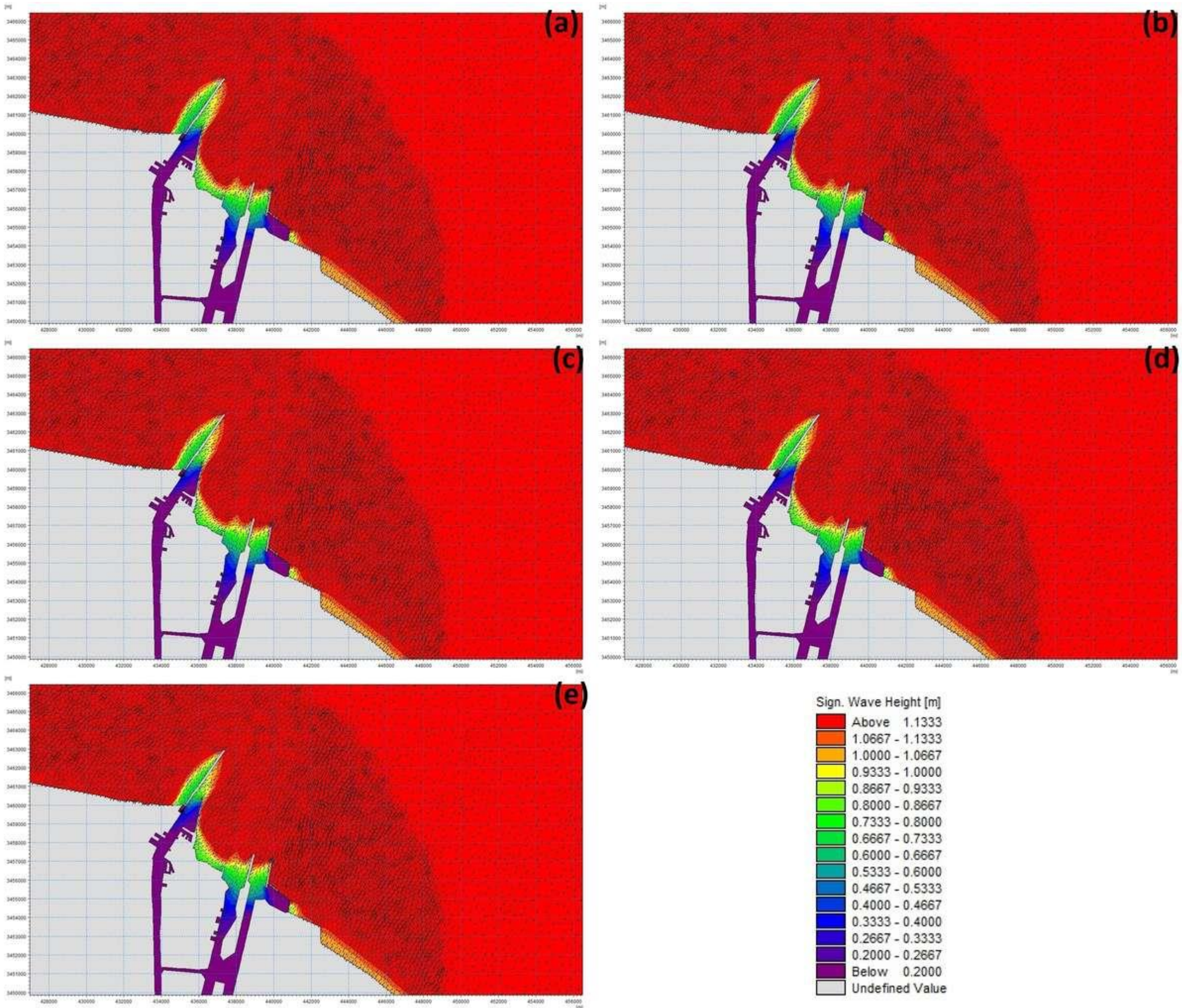

Figure 7: H_s values at the Suez Canal zone for 45° direction for different return period (a) 5 years return period (b) 10 years return period (c) 20 years return period (d) 50 years return period (e) 100 years return period.

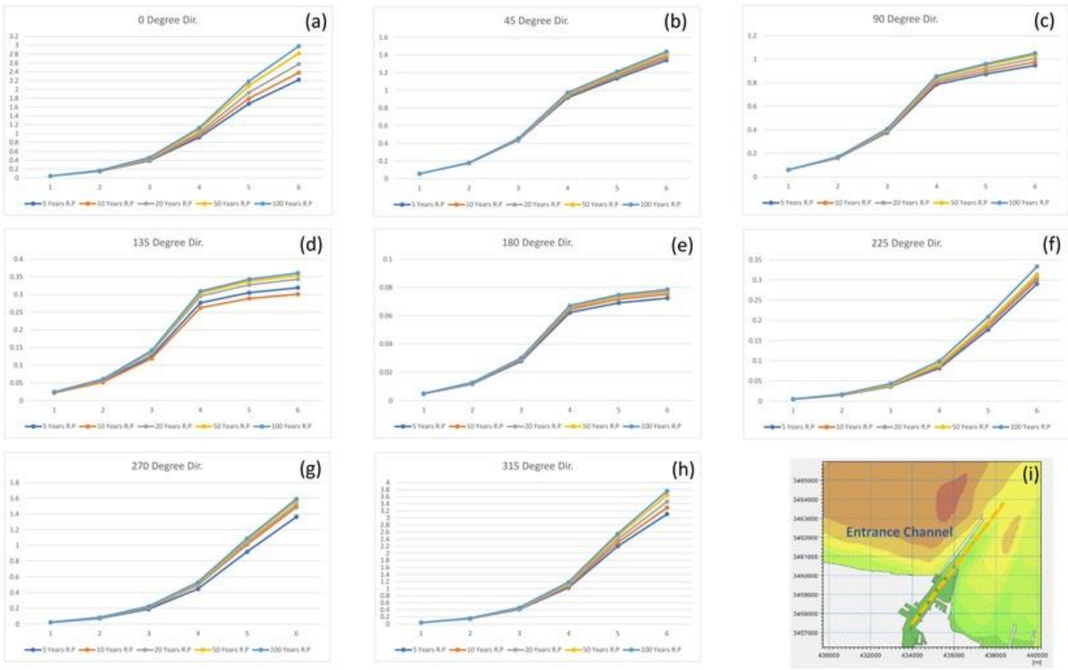

Figure 8: Analyzed H_s Values for Entrance Channel Line for Different Direction and Various Return Periods of (a) 0° (b) 45° (c) 90° (d) 135° (e) 180° (f) 225° (g) 270° (h) 315° (i) Plan View for Entrance Channel Line

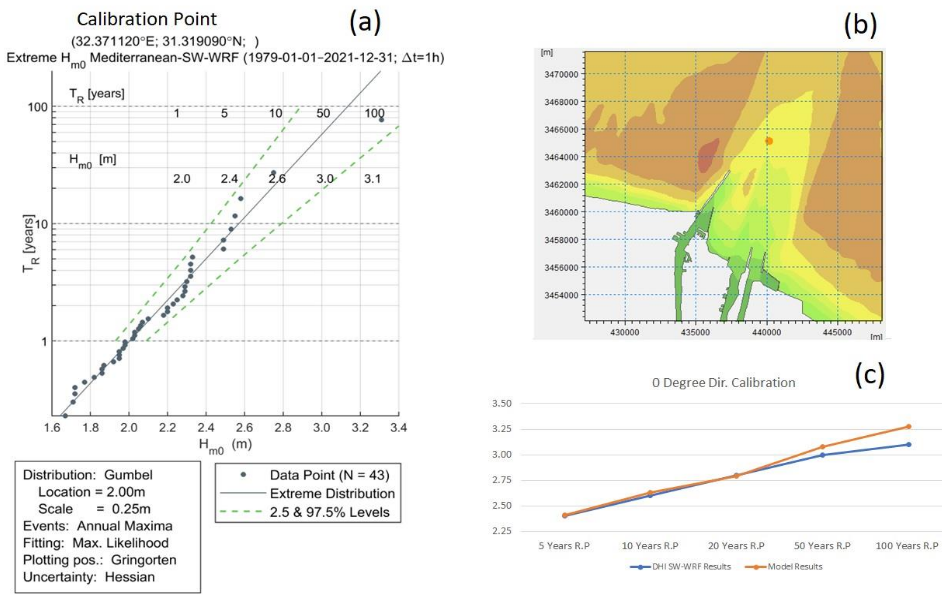

Figure 9: Calibration results (a) Results for SW-WRF Model (b) Calibration Point Location Map (c) Comparison between SW-WRF and Generated Results from the SW FM Model

Table 3. Spectral Waves Results

Return Period (Years)	*Direction (Degree)*	*Port said Touristic Port: H_s (m)*	*Port said Shipyard: H_s (m)*	*Sherif Basin: H_s (m)*	*West Port said Port: H_s (m)*	*East Port said Port: H_s (m)*	*Military Base Entrance: H_s (m)*
5	0	0.23	0.20	0.03	0.03	0.01	0.60
5	45	0.27	0.18	0.04	0.04	0.02	0.72
5	315	0.24	0.22	0.03	0.02	0.01	0.50
10	0	0.24	0.21	0.03	0.03	0.01	0.63
10	45	0.28	0.18	0.04	0.04	0.02	0.73
10	315	0.24	0.23	0.03	0.02	0.01	0.51
20	0	0.25	0.22	0.04	0.03	0.01	0.65
20	45	0.28	0.18	0.04	0.04	0.02	0.74
20	315	0.25	0.24	0.04	0.02	0.01	0.52
50	0	0.26	0.23	0.04	0.03	0.01	0.68
50	45	0.28	0.18	0.04	0.04	0.02	0.75
50	315	0.26	0.25	0.04	0.02	0.01	0.53
100	0	0.27	0.24	0.04	0.03	0.01	0.69
100	45	0.28	0.19	0.04	0.04	0.02	0.76
100	315	0.26	0.26	0.04	0.02	0.01	0.54

Modification for the entrance groin of Port said Military Base and West Port Said Port should be modified to reduce the maximum H_s of 0.60m, to ensure safe future sustainable maneuvering.

5. CONCLUSION

Green-port policies should be social, economic, and environmental to meet market needs. Several coastal international organizations and projects are raising awareness of coastal market SDGs demands. Port-cities are economically important marine hubs. Climate change impacts port adaptation and sustainability. Climate change is anticipated to increased severe wave characteristics, threatening breakwaters and groins. To examine the sustainability of ports infrastructure and build a future-proof infrastructure, ports infrastructure should be verified for its capacity to withstand the predicted severe weather events with extended lifetimes.

Port development, like Port Said Ports, should minimize long-term uncertainties related to infrastructure longevity, such as breakwater lifetime, and significant environmental impacts. This article simulates the sustainability of Suez Canal Entrance Groins using DHI MIKE21 SW FM numerical model. This model analyses a primary key performance indicator (KPI) against future predicted extreme wave conditions to determine sustainable port-city development plans.

Since the Suez Canal entry groins are approximately oriented with 30° to North, the corresponding spectral waves height values for distinct return periods of orientations 315, 0, and 45° dominate the prediction analysis. The spectral H_s values for various return periods of different directions till 100 years return period conditions are less than 0.30m for Touristic Port, Port Said Shipyard, Sherif Basin, West Port, and East Port of Port Said. H_s at the Military Base's port entrance is 0.76m. The entry groins of Port Said Military Base and West Port should be sustainability modified to minimize the maximum H_s of 0.60m for safe and sustainable maneuvering.

It is suggested to study in the future the required sustainable modifications of the entry groins of Port Said Military Base and West Port for safe and sustainable maneuvering. It is also suggested to study the expected storm surges and future sedimentations inside Suez Canal and its ports.

It is suggested study a suitable resilience risk management plan for future threatens in accordance with the main pillars od WPSP to improve and coordinate the future sustainability efforts for Egyptian Ports.

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IMPLEMENTING SUSTIANABILITY IN THE INTERNATIONAL AIRPORT OF SHARM EL-SHAIKH

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ABSTRACT

The environmental effects associated with airport construction and operational activities (such as building operation and ground service equipment (GSE)) are important to take into account, particularly in light of the fact that the air transportation sector will face greater challenges in reducing their environmental impacts as other transport sectors turn "green." According to estimates, the aviation sector contributed 2.5% of the world's greenhouse gas (GHG) emissions in 2018. Sustainability at airports is a growing field of research. The aviation and airport communities are aware of the crucial part that airport infrastructure plays in fostering positive results for both human and environmental health. Hence, the purpose of this paper is to present the impact of applying sustainability goals in international Airport of Sharm El-Shaikh and reducing carbon emissions. As a methodology, this research paper followed the qualitative approach through field visits and conducting strucutred and unstructred interviews. The main finiding showed several upgrade and expansion works have been accomplished in the airport to cope with development plans that coincided with Sharm El Sheikh City's hosting of the United Nations Climate Change Conference (COP27) in 2022.

KEYWORDS: Carbon Emissions, Environmental Degradation, Sustainability, Sharm El-Shaikh airport

1. INTRODUCTION

Over the years, sustainability concept became important as it aims at improving the quality of people' lives, protecting the ecosystem and preserving natural resources for future (Zadeh et al. ,2018). One of the major implementation science issues is comprehending sustainability. The lack of uniform terminology in the literature is one of the major obstacles to understanding sustainability. Even when evaluating sustainability, the majority of implementation studies omit to provide a concept of sustainability (Moore et al., 2017). The examination of a reference system's social, economic, and environmental aspects is commonly referred to as sustainability (Salas-Zapata and Ortiz-Muñoz, 2019).

Energy management, emissions management, water and effluents management, and solid waste management are some of the different facets related to the environmental issue. It was acknowledged that community investment, staff development, and noise control are all part of the social component. While, the economic components of sustainability are influenced by factors including economic contribution, passenger experience, airport safety, and security.

In the avaiation sector, with the development of aircraft crews, contemporary airports, security and airports departments, and airports, the sector is facing a number of parallel challenges related to technological, economic, and commercial transformations and changes. Airports in particular will be aware of these challenges. This is done in order to combat the fierce competition and emphasise professionalism in order to attain the necessary profitability and quality, which will undoubtedly result in profitability, market survival, and continuity. Additionally, it helps to sustain the infrastructure of buildings used by airports, shipping and transportation firms, and businesses that produce aircraft equipment and spare parts, as well as to achieve the best possible use of time, money, and other resources.

Sreenath et al. (2021) found that environmentally sustainable practices have greater importance than social and economic initiatives in the airport context. Thereof, this paper aims to assess sustainable practises in airports in Egypt, with refernce to Sharm El-Sheikh airport as a case study.

The airports have a huge negative effect on the environment (Ali et al., 2022) .Some of the major issues raised with regard to airport operations, such as emissions from aircraft, noise from aircraft during takeoff and landing, climate change, land use, waste disposal, energy consumption, and effects on the social structures of local communities, demand the attention of the regulatory authorities (Sreenath et al., 2021). The effects on the environment of several pollutant emissions from aircraft exhaust gases during takeoff and landing, such as carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxide (NOx), and hydrocarbon (HC) (Atasoy et al., 2021).

In 2016, Egypt's Vision 2030 was set as a national agenda launched that reflects the country's long-term strategic plan to achieve the principles and goals of sustainable development in all fields. Egypt's Vision 2030 reflects the three dimensions of sustainable development: the economic dimension, the social dimension, and the environmental dimension (Mouneer, 2021).

The motivation of this paper's research is to examine the idea of sustainable development in the Egyptian airports. Clarifying the function of sustainable development for legislators and decision-makers, who will have an impact on the standard of airport services and its overall performance, is the basis for the novelty.

2. LITERATURE REVIEW

Due to the growing importance of sustainability, numerous studies are beginning to emphasise its significance in airports (Hubbard and Hubbard, 2019). Hence, numerous airport operators have started putting sustainability efforts into practise as a result of new rules pushing airports to create sustainability programmes (Santa et al., 2020). In general, aviation plays an important role in modern social economies, providing connectivity and accessibility, and facilitating trade. Airports are critical connection points in the air transportation system and regional connectivity as well. Along with the growth of airport infrastructure, airport related business, commercial, residential and spatial development takes place in surrounding airports associated with surface transportation infrastructure (Kacar et al., 2022). It is highlighted that "sustainable airports" can be developed by incorporating the sustainability concept into the airport planning and then taking care of the airport sustainability issues and barriers.

Economic sustainability (long-term economic growth, stable employment, infrastructure development) and environmental sustainability (limiting of negative externalities—noise, pollution) of the operation of the airport are frequently in conflict with one another. As a result, airport expansion has an impact on local planning and frequently results in restrictive municipal zoning regulations that restrict possible development in the impacted region in an effort to reduce negative externalities (Batóg et al., 2019).

The use of energy is very high in airports. This is because of the sizable, equipped buildings (both in the passenger terminals and the non-passenger sections), the high demand for lighting and electric equipment, and the energy needs of the numerous facilities housed within the airport precinct. A significant amount of the energy used by airports is used by air conditioning systems. The use of air conditioning, cooling, and heating accounts for over 70% of the energy used in airport terminal buildings. This rate might be higher in places with a colder environment (Baxter et al., 2019).

Policymaking, commerce, social responsibility, the environment, and service quality are all aspects of airport sustainability (Chourasia et al., 2021). Also, the airports contribute to region's economic development, as they have a negative impact on the environment and on the communities around them. Aviation accounts for 2.5% of greenhouse gas emissions (Greer et al.,2020).

However, the operation of airports has repercussions for the environment, including noise, air and water pollution, and the use of natural resources, some of which have the potential to limit airport expansion. Also, stricter regulations on carbon consumption and greenhouse gas emissions are put in place due to growing public concern over climate change. Many airports are unable to utilise their capacity to the maximum extent as a result, especially when the mitigating cost is extremely high (Kumar et al., 2020).

The study revealed that there is a dearth of environmental indicators that are specialised in a given area, particularly civil aviation. The environmental statistics data also made it clear that without the use of environmental indicators like the environmental footprint, it is difficult to measure environmental performance effectively and address issues brought on by economic expansion. In order to clearly demonstrate the environmental impacts brought on by economic development, it was necessary to call for the development of some specialised environmental indicators in the field of civil aviation that are simplified to make things easier and easier to use in measuring environmental performance. It is obvious that the decision-maker must take these indications into account as a fundamental development factor. Table 1 shows related environmnetal Egyptian laws.

Table 1: Related Environmnetal Egyptian Laws

Environmental Issues	Laws
Noise	Article 42 of Law 4, and article 44 of its executive regulations on maximum allowable limits for sound intensity.
Air Quality	Article 40 of Law 4 and article 42 of its executive regulations maximum allowable limits for the concentration of pollutants resulting from burning of fuels. Article 36 of Laws and article 37 of its executive regulations on maximum allowable limits for pollutants in exhaust gases Article 35 of Law 4 and article 34 of its executive regulations on maximum allowable limits for ambient air pollutants.
Waste Water	Law No. 93/1962 on standards for the discharge wastewater to the sewerage network and its Ministerial Decree 44/ 2000.
Hazardous Material	Article 32 of Law 4 on handling of hazardous materials.
Waste Management	Law No. 38/1967 amended by Law No. 31/1976, and Law 4 on public cleanliness and collection and disposal of solid Waste.

Therefore, given the limitations of the researchers' knowledge, it became necessary for Egypt to be one of the top nations in protecting the environment by creating environmental strategies for the civil aviation system and beginning to identify and implement environmental indicators that help reduce environmental degradation and, consequently, the economic decline in the civil aviation sector. In fact, a number of national and international organisations (including the World Bank, the United Nations Commission on Sustainable Development, the European Environment Agency, the Authority for Economic Cooperation and Development, and other institutions) have contributed to the development of numerous indicators. Despite this and the significance of the indicators created by these organisations, the majority of them fell short of offering a conclusive model suitable for each activity or business in accordance with a particular setting. As a result, the civil aviation had to begin selecting and putting into practise environmental indicators to correspond with the growth and economic growth in the sector of civil aviation. In the egyptian airports, the development of sustainable concept is not fully applicable due to many fcators. Therefore, this paper aisms to examine the sustainable development Sharm El-Sheikh airport through applying the environmental sustainability management system.

3. PROBLEM, OBJETCIVES AND METHODOLOGY

This study examines sustainable practises at Egyptian airports using Sharm El-Sheikh airport as a case study. The following research objectives are addressed as follows:

- To study the impact of sustainable development on reducing air pollution.
- To assess the environmental sustainability management system in airport.

As a methodology, this research paper followed the qualitative approach through field visits and conducting strucutred and unstructred interviews. The interviews took place with chairs, directors, managers, emplyees and operators at the Sharm El-Sheikh International Airport, the headquarters of the Egyptian Company for Airports, which is affiliated to the Egyptian Holding Company for Airports and Air Navigation at the Ministry of Civil Aviation. This research used Sharm El-Sheikh International Airport as a case study to see the impact of applying sustainability practices in the airport. Interviewes conducted also with the head of the engineering sector of the Egyptian Company for Airports, the general manager of the technical office, the chairman of the company's board of directors, and the director of Sharm El-Sheikh International Airport. The interviews covered the following sectors:

- Crisis Management.
- Civil aviation security sector.
- Public relations sector.
- Quality management.
- Air graphics department.
- Aviation safety workers.
- Passenger service workers.
- Extension department.
- Environment and Occupational Health Department.
- Engineering Department of Sharm El-Sheikh International Airport.

These interviews made it clear that the new Sharm El-Sheikh International Airport structure is pollution-free and environmentally beneficial. The capacity of the airport to deal with environmental concerns of sustainability rises with each new terminal that is built there. Contributing to the 2022 Climate Conference is one of Sharm El-Sheikh Airport's most significant accomplishments (COP 27). Sharm El-Sheikh Airport is one of the main airports of the Egyptian Airports Company, which supports sustainable development and is environmentally friendly. and the Egyptian authorities and institutions began working on implementing sustainable practices inside Sharm El-Sheikh Airport. Due to these unique tourism aspects and proven safety measures, Sharm El Sheikh airport was selected as a case study in this paper.

4. *SHARM EL-SHEIKH INTERNATIONAL AIRPORT*

Egypt's South Sinai Governorate is home to the well-known Red Sea resort city of Sharm El-Sheikh. Due to its advantageous location at the confined entrance to the Gulf of Aqaba, the city has drawn considerable attention. Also, it has grown in importance as a travel destination due to the Red Sea's distinctive biodiversity of marine life. The airport in Sharm El-Sheikh is where the majority of tourists arrive. Accordingly, the Ministry of Aviation in Egypt began to adopt the concept of sustainable development for the United Nations Sustianable Development Goals (SDGs) policies relesead in 2015 (Perryman et al., 2022).

The Sharm El-Sheikh International Airport was developed to accommodate travellers and promote tourism, as evidenced by the following:

- The hall's capacity has been increased from 2.5 million passengers to 5 million people.
- The passenger terminal 2 has been developed.

In addition to increasing the number of customs exits in the international arrival hall from 1 exit to 2, it also included expanding the arrival hall by 1000 square metres and supporting it with 2 suitcases, expanding the international and local exit hall by 2000 square metres, expanding the travel area by 1000 square metres, and expanding the senior entrance by 1000 square metres.

In addition, the developing the passenger lounge has taken place as follows:

1. Rebuilding 40 administrative offices and a new clinic, increasing international arrival counters from 6 to 22 counters, and making counters for tourism offices and banks.
2. In addition to expanding the entrance to local travel.
3. Inspection gates and travel gates increased from 9 to 12 gates, to include 3 local gates, a transit hall gate, and 8 international travel gates.
4. Expansion of the passport counters area, passport counters from 6 to 14 passport counters.
5. Tarmac 2 and 3 were expanded at the airport, and a new one was established. A result, the airport can accommodate 67 planes instead of 46 planes.

6. Constructing an entry gate with only 4 lanes.
7. Establishing a civilized exit gate from the airport with 4 lanes.
8. Developing air production with a total area of 105,000 square meters.
9. A car parking area has been established and umbrellas have been set up with an area of 10,000 square meters.

4.1Discussion of Environmental Sustainability

The conducted interviews at Sharm El-Sheikh Airport show that there were different efforts applied to achieve the concept of environmnetal sustianbaility. This included:

First: Energy Governance

- ➢ Sources of electrical energy at the airport:

The main power source:

- Power line from the main network "Nabq Station" with a capacity of (15 megawatts).
- Power line from the main network "Al-Salam Station" with a capacity of (5 megawatts).

Backup power source: Emergency indoor stations with a total capacity of (300 kVA).

- ➢ Sources of solar energy at the airport:

ARSC has carried out a project to install a canopy above which is a solar power station with a capacity of 280 kilowatts (on high stands in the parking lot in front of Terminal 2).

- ➢ Lighting poles - solar heaters:

Solar energy is used in lighting poles of the airport wall.

There are 12 solar water heaters

Second: Airport Waste System

1. Solid waste:

- ➢ The solid waste resulting from the operation of the passenger and administrative buildings, the airside, the parking lots for buses and cars at the airport is disposed of by the cleaning company (System One), which transports it outside the airport to the public dumps in the governorate in Mandelaqa Al-Khanasir (the company does not recycle solid waste).
- ➢ Coordination is underway for the entry of Sharm El-Sheikh airport waste into the state system through a "specialized solid waste management company" (collection - transportation - sorting - recycling "safe disposal")
- ➢ Average monthly quantities of waste: approximately 160 tons

- It was directed to study finding alternative solutions to modify the path of exit of solid waste in Terminal 1 because it does not pass through the hall in front of passengers, provided that the timings for the exit of waste are determined in times other than operating times, in coordination with operations and the cleaning company.
- Sharm El-Sheikh International Airport is provided with CAN BANK waste machines.
- A study is required to sell solid waste to maximize the airport's economic return.

Third: Hazardous Waste

- Sources of hazardous waste at the airport: The Egyptian Company for Airports - EgyptAir Ground Services Company - The Egyptian Company for Aviation Services - Misr Petroleum Company). From figure 1 and the table, it appears that the waste has become increased.
- Types of hazardous waste: (oils - tires - batteries - radiation generators for X-RAY devices – waste medical generated from quarantine).
- Hazardous Waste Storage:

Fourth: Spent Oils - The quantities of spent oils are collected in drums placed in a vertical position in an environmentally safe manner

Fifth: Rubber - The temporary safe storage of the rubber is adhered to in an environmentally safe manner.

Sixth: Used Batteries - The spent batteries (dry or liquid) shall be properly placed and kept from breakage or internal acid leakage and shall be collected on wooden pallets.

Seventh: Radiation generators for X-RAY devices - they are delivered to the Atomic Energy Commission.

Eighth: Medical waste generated from the quarantine - It is collected in special bags inside the quarantine clinic at the airport and is transported through the Directorate of Health Affairs, Hazardous Waste Department, under the responsibility of the quarantine.

4.2 Waste Management at Egyptian Airports

From the conducted interviews, it was evident that the Egyptian Holding Company for Airports and Air Navigation (EHCAAN) has reviewed the most important achievements made so far in its project to develop Sharm El Sheikh Airport as passenger throughput at the facility increases. This can be displayed through:

- The company explained that the airport upgrade plan is one of its most important sustainable development projects.
- Several upgrade and expansion works have been accomplished in the airport to cope with development plans that coincided with Sharm El Sheikh City's hosting of the United Nations Climate Change Conference (COP27) in 2022.
- The airport's infrastructure has been upgraded significantly and the passenger terminal expanded to accommodate five million travelers a year.
- In line with the global trend of green transition that is applied to airports, shifting to rely on new and renewable energies, Egypt has begun procedures for converting Sharm el-Sheikh Airport into a green airport, powered by solar energy units.
- This move comes in line with Egypt's Vision 2030 to achieve sustainable development, and the hosting of the South Sinai resort's hosting of the COP27 conference in November 2022. The following figure shows the amount of wastes per operator in 2021.

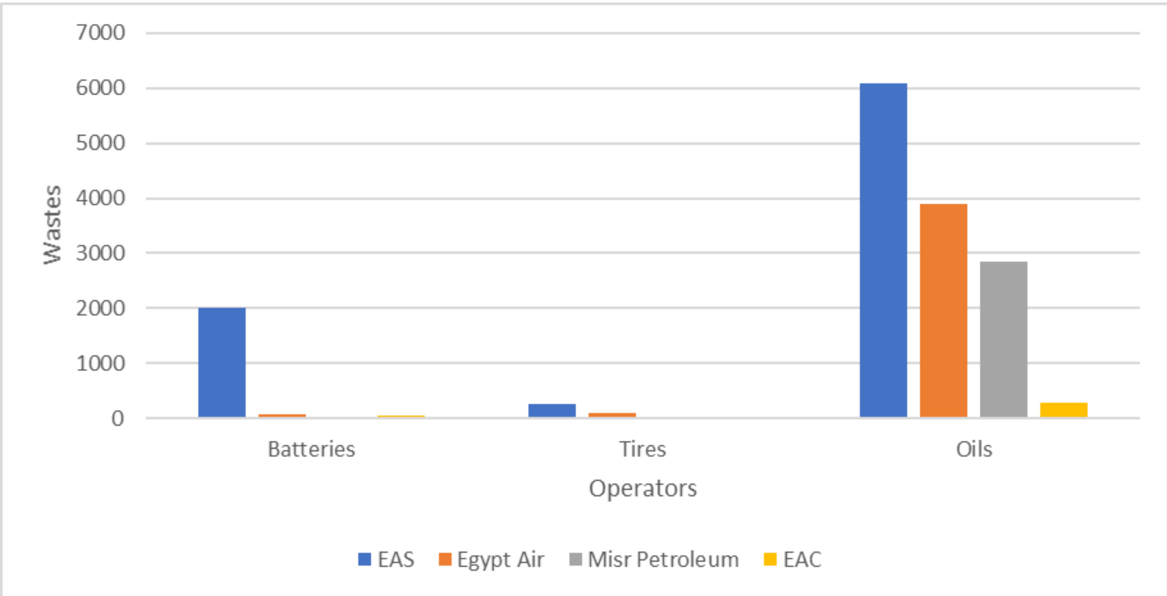

Figure1: Inventory of hazardous waste at Egyptian Airports 2021

Source: Ministry of Civil Aviation, 2022.

4.3 Findings of transforming Sharm El-Sheikh Airport into an environmentally-friendly airport

it is found that one of the projects being carried out in advance of Sharm el-Sheikh being designated a green city is the endeavour to transform the airport there into an environmentally friendly airport. Principal finings include:

- The Industrial Modernization Center's implementation of the Egypt Small Solar Cell Systems project resulted in success, and the Sharm El-Sheikh Green Airport project is a continuation of that achievement.
- The Sharm El-Sheikh Airport Project, carried out by the Industrial Modernization Center in collaboration with the United Nations Development Program, aims to promote the installation of solar cell systems in a variety of industries, including those related to manufacturing, commerce, tourism, education, and public buildings.
- Little solar power plants have been installed in Sharm El-Sheikh as a result of coordinated efforts by the ministries of energy, aviation, trade, industry, and the environment, as well as the Governorate of South Sinai and the United Nations Development Program.
- The goal of the project using modest solar energy systems is to promote the use of ecologically friendly energy and raise knowledge about how to best utilise the natural resources present in Sharm El Sheikh.

5. CONCLUSION AND FUTURE RESEARCH

Airports are working to increase sustainable development practices through reducing noise pollution, adopting indoor air quality control, and reducing the use of toxic substances. The conducted interviews revealed that the application of sustainability is very important, as it works to reduce pollution through the airport operators' endeavor to mitigate carbon emissions, reduce waste, enhance economic contribution, satisfy passengers, and meet the needs of employees.

It is concluded that Sharm el-Sheikh airport has adopted the policies and designs towards sustianability. It is recommended to adopt the concept of sustainability in airports by training to increase the practice of sustainability. For future researches, it is endorsed to benchmark between Sharm el-Sheikh airport and other airports in Egypt.

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Smart Technologies and Innovation Towards Agile Supply Chains

A STUDY FOR THE USAGE OF UNMANNED AERIAL VEHICLES (UAVS) IN SALVAGE OPERATIONS

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ABSTRACT:

Maritime transportation has undergone many advancements including the upsurge of ship values, increase of cargo volumes on board and the current mega-sized ships introduced to cater for the increased global shipping trade and align with the rising market competition. To prevent damages to the vessels in distress and to the overall environment, there is a vital need for immediate and effective salvage responses, to minimize the impact of maritime casualties and provide specialist solutions. This research aims to reduce salvage time and provide accurate, reliable and safe to obtain bathymetric information. Researcher relied on obtaining the information from scientific material in books, international publications, articles and previous studies, available on the websites and approved for reference use. Data used as the footstone of analysis in this research is mainly from public statistics in studies and authorities for the year 2020.

Keywords: Drone, Efficient, Salvage Operations.

1. INTRODUCTION

Salvage operation challenges addressed in this research include: first, in spite of having detailed bathymetric seabed charts, these charts are either outdated or considered a limited property owners who have the ability and equipment to accurately measure the seabed status. Particularly for coastal areas, bathymetry is constantly changing due to diverse natural and manmade factors. Hence, repeated bathymetric data must be obtained to reflect such changes. Traditional bathymetric surveying methods are highly labor-intensive and dangerous; such as boat-based sonar surveys that are limited by shallow water or its inability to access certain areas, which may lead to missing information between the soundings and mislead salvors about the bottom features and depth information. second, salvors are exposed to various risks during their challenging salvage operations and while obtaining of bathymetric data, including unpredictable harsh weather and sea conditions, navigating difficulties in hazardous areas that expose salvors to risk of falls, hypothermic conditions, drowning, fires, collision, injuries or fatalities etc. resulting from heavy equipment or cargo, grounding. Third, the high costs associated with salvage operations due to the use of high-tech equipment, delivery boats and a human power (Shahmoradi, et al., 2020).

Referenced studies focused on current challenges facing the salvage industry due to this increase in ship size and volume, including the gap that has developed between the increasing size of vessels (mainly container ships, passenger vessels, bulk carriers and LNG vessels) and the capabilities to effectively deal with it in case of causalities. Other challenges include the unpredictable weather and sea conditions, expensive equipment and salvage vessels required and knowledge of the seabed data. Mega container vessels, cargo vessel, crude carriers, and cruise ships, if not well managed and planned during accidents, will eventually bring in more complex operations and costs to the maritime industry.

Salvors must have clear understanding of the vessel geometry, location, cargo on-board and human life's, in addition to, reliable and updated nautical charts that illustrate the soundings, seafloor features, waves, tides and depth curves. Salvage of ultra-sized ships also require the availability of large sized salvage equipment and tug boats able to handle such ship sizes and risks the life of salvors during hazardous weathers. All of which lead to longer time for salvors to deal with the causality, plan the salvage process and deal with the diverse unpredictable on-the-spot challenges and hence resulting in more costs (Zilakos et al., 2020).

Salvage industry capabilities and equipment have developed over the past years to adapt to the greater depths, increased challenges in the salvage of huge ships, cargo volumes, nature of casualties and pollution threats. Such developments included enhanced lifting equipment, hydraulic pulling systems and rams, higher bollard pull tugboats, improved communication networks, in addition to, the incorporation of robotics and remotely operated vehicles (Potterton, 2017).

Circumstances of salvage operations during ship accidents are usually challenging, due to the complications faced by salvors in obtaining accurate and reliable information on the features of water bodies and their shorelines, the risks associated with conducting ship status investigation in order to formulate and implement the salvage plan and the high costs of salvage specialized equipment and manpower. Such challenges magnified with the presence of ultra-large container ship casualties – both in the acute stage of the emergency and in the later operational phases (Martyn, 2017).

The salvage industry's focus has evolved from servicing the private sector, which stresses vessel and cargo safety above all else, to an aggressive technique of defending the global economy and environment from any harmful accidents. This new focus is the outcome of changes in the industry's interplay with other variables one of them is overall income from salvage operations has decreased, affecting the industry's investment in salvage equipment and vessels needed to handle mega-sized vessels carrying higher volumes of cargo and/or potentially polluting chemicals, and has limited traditional salvage companies' ability to manage timely responses, moreover The lack of well-structured and safe harbour capable of receiving mega-ships in trouble has also caused ship towing efforts to be delayed, Furthermore Delays in ship hull status examinations, vessel towing operations, and overall salvage operations, which raises the danger of environmental damage.

Such delays may arise as a consequence of unexpected weather, bad vessel state, machine-driven breakdowns of the ship itself, poor towing abilities, and dangerous dangers experienced by salvers as a result of weariness, inexperience, human mistakes, and inadequate communication lines. Adding to variables, delays in ship hull status examinations, vessel towing operations, and overall salvage operations, which raises the danger of environmental damage. Such delays may arise as a consequence of unexpected weather, bad vessel state, machine-driven breakdowns of the ship itself, poor towing abilities, and dangerous dangers experienced by salvers as a result of weariness, inexperience, human mistakes, and inadequate communication lines (AGCS, 2019).

This is in addition to the complex salvage efforts required in investigating large containerships and carrying out salvage actions such as ship lifting or refloating, as well as the increase in the volume of transported cargo and toxic chemicals that must be safely emptied to avoid pollution and environmental disasters. Along with, in coastal environments that experience continuous change in the patterns of energy dispersal and related sediment transport pathways, inadequate or outdated bathymetric data and nautical charts are required to formulate the salvage operation plan, identify accurate water current predictions, and underwater status (Anwer, 2020).

Detailed charts for coastal zones are currently regarded a limited property of regional or worldwide hydrographic agencies and are not shared with the public, or they have low resolution and obsolete information, which raises navigational dangers. This reduces the breadth, quality, and efficiency of salvage operations (Wölfl et al., 2019).

Besides, Salvage businesses have limited time and resources to undertake quick water depth surveys. Reduced water depth, increased risk for divers maneuvering in very shallow rocky and rough water areas, difficulty of navigation in narrow areas, lack of specialized salvage vessels due to their

high costs and maintenance requirements, and a variety of challenges in seabed mapping using boats with remote apparatus are all factors that increase mapping time (AGCS, 2019).
It is critical for salvors to analyze seabed state, represent soundings, seafloor characteristics, and depth curves. For example, when a crane is used to raise a vessel out of the sea, it is critical to understand the boat's position, balance, and any places that might potentially break or cause injury to anybody onboard or the surrounding environment based on ship movement on the other hand, the task is expensive, difficult, and frequently takes place in treacherous seas, necessitating precision and surveying experience (NOAA, 2019).

Table (1) Classification of Salvage Operations with Risk Level and Techniques.

Type	*Risk Level*	*Technique & Equipment*
Offshore Salvage - The refloating of ships that are stranded or sunk in exposed coastal waters	Highest Risk Level - due to its exposure to opened & unprotected waters with hostile nature of waves, currents, weather etc., and vessel is prone to fast deterioration. High risks salvaging operations & exposes crew to fatal dangers.	Technique: Timely access to reliable information, accurate identification of the seabed, causality nature and evaluation of the operation constraints.
Equipment: Special salvage vessels, tugs, workboats with cranes and equipment, mobilized quickly for offshore salvage.		
Harbor Salvage - The refloating of ships that are stranded or sunk in sheltered waters	Medium Risk Level - they are not as time dependent as offshore salvages, because the weather and water conditions do not normally damage the boat, as fast as open waters do.	Technique: Clearing out the passage if required for clear navigation of the causality and seabed, if required.
Equipment: Floating cranes, barges and any required heavy equipment's and manpower		
Cargo & Equipment Salvage - Saving cargo & equipment is of higher priority than saving the vessel itself.	Highest Risk Level – Saving cargo and equipment on-board is a priority as it may pose an environmental hazard or include expensive materials	Technique: Rapid removal of goods includes deliberate dissection, disassembly or destruction of the hull.
Equipment: expensive materials such as machinery, motors etc.		
Wreck Removal - Clearing the seabed from hazards or wrecks that have little or no salvage value.	Low Risk Level –focuses on the removal of hazardous or unsightly wrecks that have little or no salvage value and hence has the least or no risk level.	Technique: wrecks are refloated or removed by the cheapest and most practical method, while hazardous materials are removed prior to disposing of the wreck.
Equipment: barges, tugs, cranes, accommodation barges and ancillary equipment		
Afloat Salvage - Salvage of a vessel that is damaged but is still afloat.	This type of salvage is mostly unobtrusive; it does not involve challenging exertions.	Involves damage-controlling, primary repairing tasks like the hull welding & stabilizing by rebalancing ballast tanks, shifting cargo & structural bracing.
Clearance - Salvage of casualties in a harbor or waterway, after catastrophic events like Hurricane, Tsunami, and War etc.	Variable Degrees of Risk / damage due to events like fire, collision, or explosions etc. most commonly takes place after severe weather conditions.	Shipwrecks are scavenged or removed coordinately to clear out the passage in a harbor or waterway that can be blocked for navigation by multiple obstructions.

Source: (Bartholomew, 2013; Duffy, 2018)

Last but not the least Capsizing – extreme motion of the ship and waves and sinking of salvage vessels occur for a variety of reasons, including a mismatch between the calculated Bollard pull (BP) – the tug's pulling capability – and the tug's actual operational BP, erroneous positioning of the tug relative to the assisted unit, overspeed of the assisted larger vessel or barge, and insufficient communication between the vessel (Freyermuth et.al., 2012).

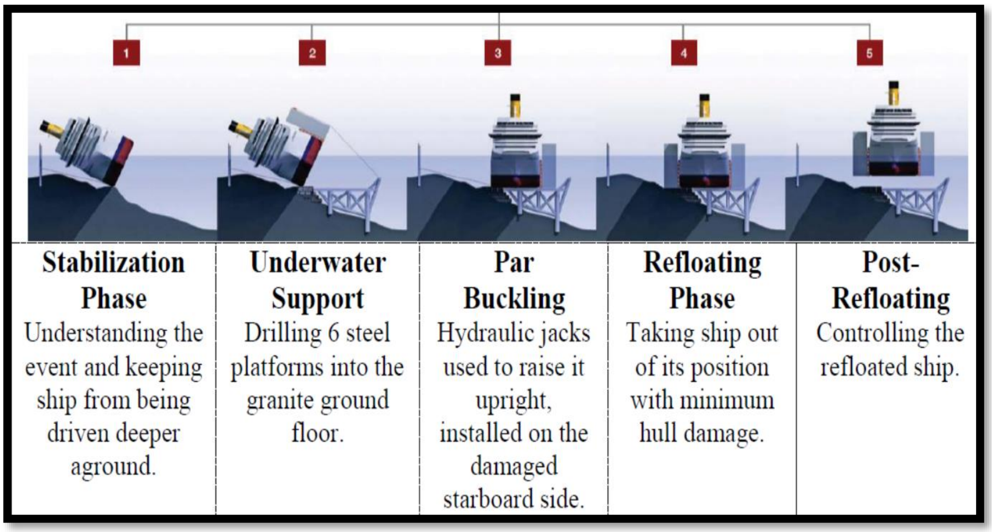

Figure (1) Phases of Costa Concordia Salvage Operation.
(Source: Smith et al., 2014).

Preparing for and responding to disasters and maritime causalities is a major logistical challenge, for which many organizations are now adopting the use of UAV (Drone) to enhance the efficiency of such responses. This research has explored the latest literature in the use of various types of drones in such operations, the different views supporting drones' integration in maritime salvage and wreck removal based on real case studies of the latest drone usage. It had provided salvors with immediate, accurate and updated data and has opened up a world of possibilities in collecting data, to complete a picture that was previously difficult and time-consuming to obtain and error-prone.

The cases illustrated in earlier, whether for the various maritime industry fields that have benefited from the integration of LIDAR sensors with UAVs or from analyzing the challenges faced in salvage operations that could have been resolved with the use of drones, revealed that drones provide close to real-time information within reduced time-frames and risks to salvors, which ultimately mean improvements in operations and results management, a better understanding of the dynamics of the environment and the overcoming of severe weather restrictions, such as clouds, that limit other remote-sensing platforms.

2. PROBLEM DEFINITION:

Dangerous missions performed by salvors demand continuous research and employment of new technologies to tackle the salvage mission challenges and ensure efficient information for formulating salvage plans. Situation of ships that are stranded or sunk in exposed coastal waters is the most vulnerable and very difficult to work on, due to their exposure to opened, unprotected waters and the hostile nature of waves, currents, weather etc. that hinders the salvage operations & exposes crew to fatal dangers. It also encounters rapid deterioration of the vessel and is time consuming, with limited ability to deploy bulk equipment's for the salvage usage.

The situation of ships that are stranded or sunk in exposed coastal waters is the most vulnerable and very difficult to work on, due to their exposure to opened, unprotected waters & the hostile nature of waves, currents, weather etc. which hinders the salvage operations & exposes crew to fatal dangers. It also encounters rapid deterioration and is time consuming, with limited ability to deploy bulk equipment's for the salvage usage. The key salvage operation challenges addressed in this thesis include:

Due to the limitations of using UAVs (Drones) in Egypt, no real time experiments or interviews have been done to support the study, rather, international experiments, publicly available material and real cases have been mentioned:

a. ***The lack of updated or accurate nautical charts, especially in coastal areas, which limits the quality and efficiency of the salvage operations and leads to costly decisions***

In spite of having detailed bathymetric seabed charts, these charts are either outdated or considered a limited property for certain owners, who had the ability and equipment to accurately measure the seabed status. In addition, especially for coastal areas, the bathymetry is constantly changing due to diverse natural and manmade factors. Hence, repeated bathymetric data must be obtained to reflect such changes.

Traditional bathymetric surveying methods are highly labor-intensive and dangerous, requiring surveyors sometimes to swim and dive in the water, while boat-based sonar surveys are limited by shallow water or the inability to access a certain area, all of which may lead to missing information between the soundings and misleads salvors about the bottom features and depth information.

The latest mapping techniques of Airborne LiDAR or Satellites is much more efficient than ship-borne sounding methods and underwater photogrammetric methods, especially in shallower clear water areas, due to its ability to obtain features in coastal regions such as tidal levels, coastal dunes, rock platforms etc. but still involve high costs that are not affordable by all users.

b. ***The risks salvors face in performing real-time bathymetric mapping, investigating the ship in distress, performing towing activities etc.in addition to, the time and resources allocation.***

Salvors are exposed to various risks during the allocation and obtaining of bathymetric data, including unpredictable harsh weather and sea conditions, navigating difficulties in hazardous areas that expose salvors to risk of falls, hypothermic conditions, drowning, fires, collision, injuries or fatalities etc. resulting from heavy equipment or cargo, grounding.

c. ***The high costs associated with salvage operations due to the use of high-tech equipment, salvage and delivery boats and a number of human powers***

The Safety and Shipping review considered an imaginary worst-case scenario for a maritime casualty, involving collision and grounding of two vessels, followed by an environmental pollution. An approximate salvage cost has been estimated for several tasks such as wreck removal, cargo liabilities, bunker removal, litigation and crew liabilities (Figure 1-1). Both vessels have been considered as a constructive total loss with an estimated accumulated loss of 4 billion dollars (AGCS, 2019).

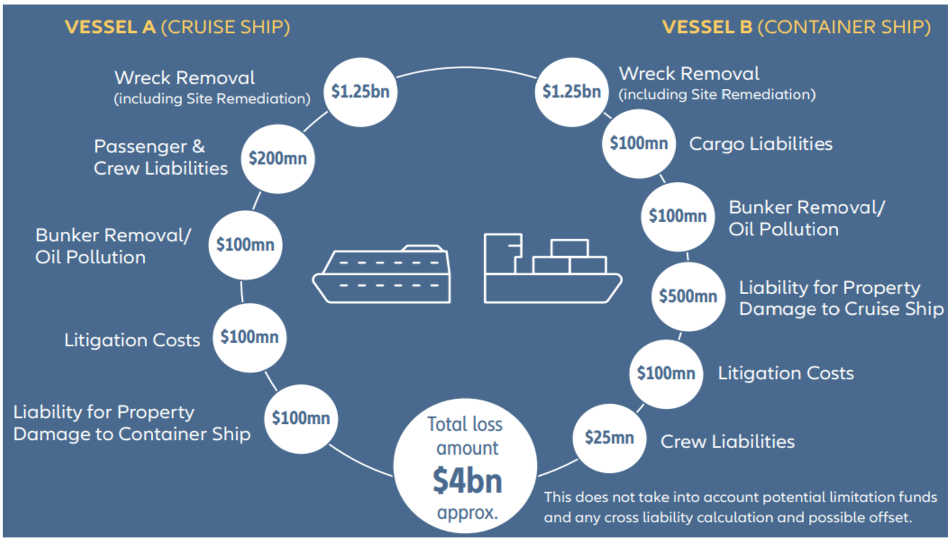

Figure (2) How a $4bn Loss Scenario Could Occur.
(Source: AGCS, 2019)

3. RESEARCH OBJECTIVES:

This research has focused on answering the following questions:

1. What are the major challenges facing salvors?
2. How will the use of Unmanned Aerial Vehicles (UAVs) aid salvors?
3. What are the current UAVs used in the maritime industry? Moreover, what are the major limitations of UAVs in various salvage missions?

This research aims to enhance the efficiency of salvage operations. Research objectives are follows:

1. To discuss factors required to accomplish the salvage mission, including equipment and expertise required.
2. To find out the challenges faced by the salvage industry that led to delayed responses and life-threatening risks on various shipping actors.
3. To present the possibility of solving these problems using Drone.

4. STUDY ANALYSIS:

Researcher depends on a descriptive analytical method; by obtaining information needed from scientific material in books, international publications, articles and previous studies available. Data used as the footstone of analysis in this thesis is mainly from public statistics in studies and authorities for the year 2020.

The majority of papers on drone integration have gone into detail about the technology's possible usage and future applications. According to studies, all stakeholders involved should consider the use of drones in salvage operations, including shipowners, the ship design industry, salvage business, liabilities and insurance companies (Olaf, 2019).

Drone projections, according to reviews, cannot rely on past data because their operation and reliability are based on immediate obstacles encountered during the salvage mission, which varies from mission to mission and cannot deliver consistent results. Experts have been able to identify the issues that have surfaced through the employment of drones in a variety of tasks, but these will continue to vary depending on environmental changes.

Replacing Traditional Salvage Methods with UAVs that can be remotely operated or fly autonomously based on pre-programmed flight plans to perform dangerous salvage jobs on ships and offshore structures, replacing large, expensive dedicated salvage equipment. Salvage activities are completed in a fraction of the time that traditional methods would take, and photographs are processed swiftly in the cloud, allowing for speedy judgments.

1- The challenges faced by salvagers in refloating the MV Höegh Osaka, where salvage tug boats were unable to reach the vessel in distress due to mooring ropes floating in the water surrounding the vessel stern and inclement weather, could have been resolved by using drone technology to connect the vessel tow lines, thus improving overall salvage mission efficiency, avoiding the need to maneuver in hazardous zones, and reducing the time required.

2- Workers suspended on ropes inspected the tank structure, focusing on areas of high stress such as stiffeners, brackets, bracing, webs, and stringers, and assessed the coating condition to check for corrosion and damage within the tank during the delayed inspection of the "Modern Express" vessel and visual inspection of cargo tanks. All of this could have been done in a fraction of the time by using collision avoidance and obstacle detection drones to remotely investigate the ship's interior condition and reduce the risk of life-threatening situations for salvors during their initial assessment and final implementation of the salvage plan.

3- Drones may have also been a useful tool during the examination of "Lady Emma," with all of the essential payloads attached and allowing the crew to see everything.

4.1 LIDAR Drones for Bathymetric Data

LIDAR sensors integrated in drones provide 360-degree visibility rotating around a dedicated axis with a powerful data collection engine that allows survey operators to collect both sensor types in real time, see the full picture above and underwater in 3D through the Real Time Cloud viewer, and thus maximize their LIDAR sensor investment by increasing the sensors' modularity. This is in addition to their obstacle detection, collision avoidance technology, and ability to carry various equipment such as cameras, Global Positioning Systems (GPS), navigation systems, and so on, allowing for the accurate detection of water depths at lower altitudes and slower flight speeds for large and difficult-to-reach water areas.

As a result, UAVs offer a cost-effective option for remote, small, and localized ALB studies. Combining aerial LIDAR with an IMU (inertial motion unit) and a GNSS receiver, which provide information about the position, rotation, and motion of the scanning platform with high relative accuracy, is required to achieve a high level of accuracy.

4.2 Drones for Surveying Tanks and Confined Spaces

Using a UAV (drone) to replace traditional methods for conducting high-risk and difficult tasks such as surveying tanks and confined spaces on ships eliminates the risk of damage to the coating, expedites survey tasks, reduces downtime, eliminates costly and time-consuming workarounds for surveyors, and allows for the investigation of huge tanks on ships that are more than 25 meters tall. Scaffolding, hanging staging equipment, and other specialized solutions, such as portable gas detectors, would have been necessary for such operations, all of which would have to be examined and approved for safety at a considerable expense (Iliaifar, 2018).

4.3 Reduced Costs during Salvage Operations

Using a single drone for a single salvage mission, along with the appropriate sensors and payloads, allows salvors to easily approach projects in areas that are difficult, dirty, or dangerous to access, while also overcoming the limitations of both ground-based and space-borne hydraulic observations and assisting salvors in various other mission tasks such as investigations, immediate image providing, and so on.

Drones have replaced a variety of equipment and are readily available to perform immediate missions, as well as risk reduction in the harsh maritime environment by eliminating the need for direct human presence in the area of inspection, reducing the likelihood of injury in high-risk situations, allowing work to continue uninterrupted in active work zones, and enabling data collection that previously required extensive groundwork or very expensive manned aircraft, in a cost-effective manner.

Future Steps for Incorporating UAVs in Salvage Operations:

Nowadays, UAV technology is expanding, and individuals have begun to see the technology's promise in a variety of businesses. Drones are adaptable and can perform a wide range of tasks. The usage of drones in salvage operations has become increasingly popular due to the high capital costs of specialist salvage equipment and the increased risks that salvors face. They have become commercially available because to significant cost reductions and better performance of practically all of their important sub-systems. In order to safely and efficiently introduce UAVs (Drones) into ship salvage operations, the salvage industry must be able to address and overcome the following obstacles:

1- The UAVs to be approved and legalized in home country as Before operating a drone for any reason in Egypt, permission must first be sought from the Civil Aviation Authority, according to Law No. 28 of 1981, which was updated to include drone laws by Law No. 92 in 2003. Drone use in Egypt is strictly regulated, and there are a number of Egypt drone rules and procedures that must be followed before and during flights in the country.
2- the incorporation of UAVs benefits the salvage industry financially (in terms of salaries, expenditure of time and equipment), while the available ship salvage budget greatly differs, locally between different salvage companies and internationally depending on the different country economies. However, as confirmed by all articles and studies, the drones' market will

highly increase over the next five years, fueled by increasing price competition and new technologies that make flying drones easier and cost effective. This will especially be applicable in the US and Europe markets due to their open markets and easier approaches to new technologies. In terms of reduced salvage operation costs that will be reflected by incorporation of drones, the following points summarize and confirm it through:

a. Drones are typically operated by one person without any extensive safety equipment, meaning the costs associated with the salvors salaries and equipment can be significantly reduced. Each salvage company may in that case calculate the cost of incorporating high-tech equipment versus incorporating UAVs to efficiently accomplish the mission.
b. Replacing salvage vessels with drones for emergency deliveries during salvage operations could help to reduce costs by up to 90% for vessel operations and ship managers. Wilhelmsen Ships Service (WSS) agency researches have revealed that launching a boat for ship deliveries would cost an average of $1500 - $4000 per hire, depending on port locations, while the use of drones for such missions may decrease the cost to $150 per hire or save the maritime industry an average of around $675 million (Martyn, 2017).
c. Using UAV technology to gather data for inspection purposes prior the implementation of salvage operations may also provide a potential saving of $1 million-plus daily savings, especially for certain oil and gas clients (Martyn, 2017)

3- Choosing UAV (Drone) technology and the corresponding LIDAR sensor would be beneficial for the salvage industry missions depends on the salvage operation case, environmental conditions, delivery terms, and budget among other factors. LIDAR manufacturers are developing lighter, more compact sensors suitable for this market (traditional sensors weigh 60-300kg), enabling UAV flight and leading to increased flight endurance. Turbidity is still a factor for depth performance and bottom detection, but with lower mobilization costs, end-users are more willing to test the performance in these environments.

4- The UAV (Drone) technology can be obtained in "Fugro", "RIEGL" and "ASTRALiTe" are all examples of companies which have recently developed sensors targeted UAVs. Drone technology already exists from big manufacturers such as "DNV-GL", "Lloyds Register" & "Maersk", who have already proved their ability to overcome several challenges and perform salvage operations efficiently, access difficult-to-reach areas safely, deliver real time data, ensure high accuracy and spatial resolution in monitoring surface water bodies, allow easier access and capturing volumes of highly accurate data at a limited cost and with high flexibility, and aid in the close-up inspection of hard-to-reach structures, rugged terrain, and remote sites, hence obtaining a clear picture of the casualty status and eventually being able to develop effective salvage plans. Martek Marine supplies drones for a range of applications, including tank and external vessel inspections, with high definition and infrared cameras and high collision-tolerance that can be used to safely access confined spaces. Overall, the choice of the drone and its corresponding payload will again depend on the type of mission, the tasks required and the available budget

5- Training will be required and should be implemented however The Salvage industry must develop a complete guide to drone purchasing/drone services based on the researchers' specific needs and on the legal requirements and limitations. The guide must then be distributed to all related salvage units and be coupled with offers to test flying drones in a safe environment. Interested researchers would be put in contact with an independent drone purchase advisor who would recommend the service or product most suited for the customer's need. While drone training is sometimes included with the purchase of more expensive drones, there are very limited training opportunities for those who wish to purchase a more specialized drone

4.4 UAV Benefits in Salvage Operations

Unmanned Aerial Vehicles (UAV) are currently used to provide real-time data in salvage operations including the inspection of physical structures, identification of buoys, pipes, docks, breakwater cranes, roof-ships and other structures maintenance requirements, calculation of (bulk) volumetric mass inventory, detection of irregular situations, leaks or abnormalities through (thermal and gas) sensors, provide accurate and quick detection of ship location and/or contamination, search and rescue operations and seabed mapping and surveying, especially when adding a GPS/INS sensors. These missions are accomplished without the need to risk salvors lives in hazardous situations (Frederiksen & Knudsen, 2018).

UAV contributed significantly to risk reduction by performing high risk tasks in a safe manner (such as inspections in dangerous areas), offering effective operation in harsh maritime environment with its ability to withstand storm force wind and heavy rain, snow and salt spray, without requiring direct human presence in the area of inspection, reducing the likelihood of injury in high-risk situations and enabling work to continue undisturbed in active work zones.

A LIDAR sensor mounted on a UAV, along with the LIDAR software can process images very quickly in the cloud, allowing for effective decisions to be made by stakeholders and relevant parties. The output from these LIDAR drones and sensors is outstanding. The pace of development and improvement in the LIDAR sensors over the past few years has been tremendous and will continue with more entrants into this sector (V. Klemas 2015).

Overall, UAV aids salvors and hydrographers in several ways; being an inexpensive and accessible method of obtaining point-cloud data and increased capability of maneuvering difficult environment, with no limitations as with bulky aircraft outfitted with LIDAR.

4.5 Challenges Facing the Use of UAVs (Drones) in Salvage Industry

The main challenges facing the UAV industry include (Duffy, et.al., 2018 & B. Custers et.al., 2016):

- Safety of its operations in crowded areas or at very low altitude and invading of privacy and security are factors limiting its official legalization in many countries.
- The need for users to have a full understanding of its operations, the sensors suitable for accomplishing each mission and the expertise in interpreting the resulting data efficiently by surveyors.
- In case of large oil tankers and huge cargo volumes, the pilots are surrounded by lots of steel, which negatively affects the GPS and magnetic compass accuracy (main equipment used to identify and aid the UAVs positioning), causing unpredictable UAV movement and vulnerability to any sudden shock or weather change.
- The harsh weather conditions (such as Tsunamis, Hurricanes, or terrorist attack) may also cause deviations and erroneous results, but is currently resolved by the introduction of shock resistant drones, able to face such difficult weather conditions.
- Energy consumption and battery operation used for hovering, wireless communications, data processing and image analysis, are limited by the drone type and the mission requirements but their limited operating time may still be a major drawback for extended periods of time over disaster-stricken regions.

4.6 Experiments Supporting Use of Drones in Salvage Operations

Replacing the need for human inspections, routine maintenance can be monitored remotely in real-time by surveyors, providing instant feedback to salvors and in turn, reducing costs, increasing efficiency and significantly reducing the risk to human life during initial response phase. UAV applications in salvage operations have been indicated in the following cases:

4.7 UAS Topo-Bathymetric LIDAR Surveys

Traditional survey methods for collecting bathymetric data in shallow water areas, such as Riverine environments, have proven to be highly labor-intensive and dangerous, as salvors had to swim and dive in the water to collect cross-sections of depth measurements, in deep or fast-moving areas. Boat-based sonar surveys used earlier, was limited by shallow water, rapids, or inability to access certain areas, such as "Whychus Creek", which is a remote stream that would be time-consuming to ground survey but was effectively and safely mapped with the BathyCopter.

The purpose of this project within this case was to evaluate the use of UAV platforms combined with interchangeable bathymetric and terrestrial laser scanning sensors, to support Riverine Mapping applications. This has been done by testing the Riegl's Bathymetric Depth Finder (BDF-1) and Riegl VUX-SYS laser scanning system, in three distinct riverine environments, on October 2015, at the Pre-Alpine River (Pielach in Lower Austria), by combining data about water depths and surrounding land elevation, out of which Bathymetric results have been presented.

Experiment was designed and executed to illustrate the accuracy range of UAV platform, reliable detection of water surface and resolution of the river mapping. A 200 m longitudinal section and 12 river cross sections were 51 measured with the BathyCopter sensor system at a flight altitude of 15-20 m above ground level and a measurement rate of 4 kHz. The 3D laser profiler points were compared with data acquisitions using the Riegl VUX1-UAV lightweight topographic laser scanning system (bare earth, water surface) and terrestrial survey (river bed). Logistical considerations of the project included evaluation of water clarity, movement obstructions (trees, powerlines etc.), sensor swap, ground trothing and drone battery life (Mandlburger et.al., 2016).

4.7 RIEGL's Remotely Piloted Ricopter Platform

The RiCopter's main features included offering a flight endurance of 30 minutes per battery, with batteries that can be quickly swapped to enable sequential missions at each location, offering a maximum flight altitude of 400 feet and continuous line-of-sight with the aircraft. Sensor system (Riegl BathyCopter) included a laser range finder, an Inertial Measurement Unit (IMU), a Global Navigation Satellite System (GNSS) receiver, a control unit, and digital cameras mounted on an Octocopter UAV (Ricopter).

The range finder operates on the time-of-flight measurement principle and utilizes very short laser pulses (<1 ns) in the green domain of the spectrum (λ=532 nm) for measuring distances to both the water surface and the river bottom. VUX-SYS is a topographic LIDAR sensor (=1064 nm) designed for UAV applications and has a field-of-view of 230 degrees and a PRF of 350 KHz. BDF-1 pulses a green laser (= 532 nm) at an 8 degree off NADIR look angle and a depth rating of 1.5 Secchi depths. The sensor has a pulse repetition frequency (PRF) of 4 KHz, but averages every 10 pulses, resulting in an effective PRF of 400 Hz. The UAV-based sensors were evaluated for their potential to efficiently collect channel geometry in areas where the water was not easily accessed or it was too dangerous to use ground- or water-based methods.

If planning to use drones in the future, it is important to focus on the changes to the regulations, improvements in technology (hardware, software and firmware) and advances in data collection methodologies and analysis, along with ensuring compliance with all regulations. It is also very important to have trained and specialized salvage teams to efficiently benefit from all drone features and specifications and allocate the suitable drone payload for each mission. On-going training and updated market knowledge are necessary to keep track of all drone advancements.

5. CONCLUSION AND RECOMMENDATIONS:

Drones are holding more roles in the maritime industry day after day and their growth in the commercial markets is expected to continue. Improving safety, providing instant data and accurate readings, reducing costs, speeding up processes and allowing safe operations are a few on much more benefits from incorporating drones in the maritime industry.

Authors found that; there are main challenges facing the UAV industry include:

A. Safety of its operations in crowded areas or at very low altitude and invading of privacy and security are factors limiting its official legalization in many countries.
B. The need for users to have a full understanding of its operations, the sensors suitable for accomplishing each mission and the expertise in interpreting the resulting data efficiently by surveyors.

C. In case of large oil tankers and huge cargo volumes, the pilots are surrounded by lots of steel, which negatively affects the GPS and magnetic compass accuracy (main equipment used to identify and aid the UAV's positioning), causing unpredictable UAV movement and vulnerability to any sudden shock or weather change.
D. The harsh weather conditions (such as Tsunamis, Hurricanes, or terrorist attack) may also cause deviations and erroneous results, but is currently resolved by the introduction of shock resistant drones, able to face such difficult weather conditions.
E. The drone type limits energy consumption and battery operation used for hovering, wireless communications, data processing and image analysis, and the mission requirements but their limited operating time may still be a major drawback for extended periods over disaster-stricken regions.

Authors recommended that:

- Governments and businesses should build necessary infrastructure to improve businesses.
- Efforts have to be made to make spectrum available for the usage of drone in order to accommodate the international usage od drone.

This research is limited, Due to the limitations of using UAVs (Drones) in Egypt, no real time experiments or interviews have been done to support the study, rather, international experiments, publicly available material and real cases have been mentioned.

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DATA BASED PROPOSAL FOR A HYDRODYNAMIC SHIP MODEL TESTING FACILITY IN THE ARAB REGION

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ABSTRACT: This research aims to review current challenges with regard to enhancing Arab ship design and building capabilities, with focus on how to be a smart buyer, and provide insights towards sustainable shipbuilding industry with quality. This requires an understanding of both what is needed and what can be achieved together with a process that allows this to be done as efficiently as possible.
The objectives of the project are to research hydrodynamic facilities as a whole and their particular utilisation from a maritime security perspective. Links between similar projects in other maritime maritime sectors shall be drawn to construct a benchmark for the desired hydrodynamic facility outputs and vessel categorizations for the Arab maritime sector's vision 2023 – 2050. The proposed process philosophy addresses part of the problem, i.e. matching needs, quality and affordable ships. The solutions are concluded from a total of 46 hours of recorded interview data that was gathered and fine-tuned. Common denominators were drawn between the answer categories and a total of 17 responses were the key areas that the participants made note of were analysed and postprocessed according to the order of importance for the responses in the questionnaire. These participants ranged from past, current and upcoming mid-level up to leaderships at their organisations oriented with the strategic planning and the technical restructuring of the fleet to adhere to the projected technical and operational challenges in sea going operations for the next 30 years. A conclusion of the findings guided the study towards the need of advancing the hydrodynamic facilities in the Arab World with a proposed design of a towing tank and thorough business plan for the decision makers to consider.

Keywords: Smart Ship Buyer, Ship hydrodynamics, Towing tank, Ship design, Shipbuilding

1. INTRODUCTION

United Nations Conference on Trade and Development (UNCTAD) has reported a growth in the global merchant fleet by 63 million dwt in January 2022 when compared with previous year. The current total carrying capacity by the world merchant fleet has reached 2.2 billion DWT, with Greece at the top of the market share holding 18%, followed by China with 13%, Japan 11%, while Singapore and Hong-Kong with 6% and 5% respectively, i.e. half of the world's tonnage is owned by Asian companies and approximately 39% is owned by European owners. This increase in the demand of efficient vessels would shedlight on the opportunities for developing nations to enhance their economic growth through investing in the blue economy and building competitive ships.

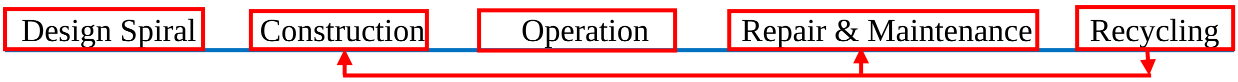

Fig. 1: Stages of ship life cycle.

This paper aims to address the capability of the Arab world in designing and building efficient ships, as such the work is focused on key elements influencing shipbuilding industry, such as research hydrodynamic facilities as a whole and their particular utilisation from a maritime industry perspective. Links between similar projects in other maritime sectors shall be drawn to construct a benchmark for the desired hydrodynamic facility outputs and vessel categorizations for the Arab maritime industry sector's vision 2020 – 2050.

Although. limited hydrodynamic facilities recently constructed and installed in the Arab region, such as in 2019, the Military Technical college in Cairo installed a towing tank that features 8x700mm hinge depth absorbing flaps in a 50m long tank with a towing carriage able to run along the full length of the tank. Following the MTC's tank the Khalifa University Center for Robotics and Autonomous Systems was established in 2021 to conduct pioneering research in robotics relevant to industry and society. The tank features 32×1.8m paddles in a double ended arrangement. 12 flow ducts provide flow across the width of the tank. The tank is 8m wide x 18m long x 3m deep (Edinburgh Designs, 2023). The Arab region has potential to compete with the global market in designing and building region's need of commercial vessels, if adequate hydrodynamic facilities exist, e.g. wave basins, bigger towing tanks (Rakesh, 2019) and (Day et. al, 2015), and cavitation tunnels (Terwisga. 2007) and (Brandner et al., 2007)

This research will focus on investigating challenges in designing and building efficient non-SOLAS vessels, i.e. vessels < 400 GT, such as tug boats, offshore supply vessels, fishing boats, yachts, RO-PAX ferries, and high-speed patrol boats. Most of the mentioned vessels are designed by overseas partners and some of them are built by Arab shipyards. However, such proven hull vessels are not amended to particularly suit the zone areas where they are going to operate, as such this paper is a step forward towards owning an Arab hydrodynamic facility by detailing the design of a proposed towing tank and by providing decision makers with business plan and expected expenses.

2. METHODOLOGY

In order to construct the optimal path four phases methodology was applied as shown in Fig. 2. The research methodology implied to achieve the research objectives were broken into 4 phases as follows:

Phase 1: An introduction explaining the Arab region's coastal operation parameters, literature review and the research questions. In addition, an identification of suitable organisations and specialists to contact during the questionnaire phases.

Phase 2: Questionnaire for group "A", i.e. maritime experts, policing and users and group "B" for hydrodynamic research providers and managers.

Phase 3: Analysis of the findings for phase 2

Phase 4: Developing the required hydrodynamic capabilities and parameters.

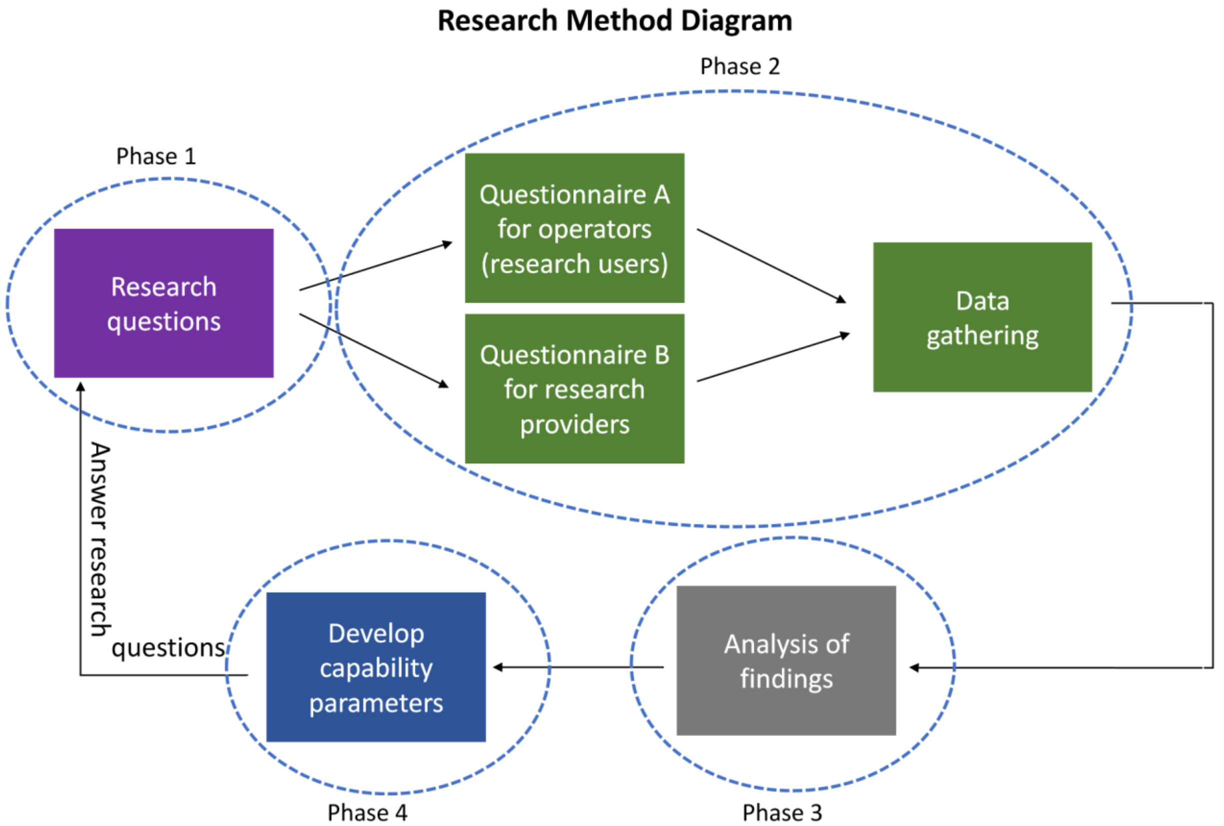

Fig. 2: Diagram showing the research method approach devised to reach research question objectives.

2.1. Questionnaire Set-up

Outcome of the questionnaire of group A, i.e. that was directed towards maritime industry, policing and users. A total of 23 current and past members of the maritime industry were interviewed. These participants ranged from past, current and upcoming leaderships at their maritime organisations oriented with the strategic planning and the technical restructuring of the fleet to adhere to the projected technical and operational challenges in sea going operations for the next 27 years. Three interviews were also conducted with hydrodynamic facility directors/ managers. A total of 46 hours of recorded interview data was gathered and fine tuning was arranged. Common denominators were drawn between the answer categories and a total of 17 responses were the key areas that the participants made note of were placed in a graph to show the order of importance for the responses in the questionnaire as shown in table 1.

Fig. 3 presents a summary bar graph that was drawn to arrange the 17 responses N1-N17 and show an effective representation on the importance of each highlighted ability category mentioned in the interviews.

Table 1: Showing key capabilities within the shipbuilding industry:

Response#	**Capability Highlighted**
N1	optimization balance between budgets and needs
N2	the ability to independently differentiate between the presented hulls during tendering
N3	model and computational testing assessment for those hulls during various conditions needs to be conducted to understand the full scope of how these hulls perform
N4	ability to understand the effects of the varying mission speeds on the hulls performance in calm waters and waters up to sea state 3.
N5	in house computation assessments to understand the performance nature and the performance loads on the operation
N6	assess how a particular hull would perform if the nature of the loads required have not been incorporated in a previous design and to ensure that these changes will yield optimal results
N7	To have accurate performance and sea keeping data presented on charts to compare how the hull would perform if it was to be made out of various metals or GRP, in order to ensure which path to take with the hull material and conduct inhouse assessments of such hull factors.
N8	The ability to compare various hull data from various shipyards during tendering and make selection based on the hull performance data and be able to analyses it
N9	Better understanding of mission roles
N10	The ability to translate mission profiles into hulls and designs that achieve the required performance in terms of operational speeds, seakeeping and withstanding loads
N11	The ability to differentiate between various designs and compare the operation nature in waters from 3 – 50 metres in depth
N12	The possibility to enhance existing hulls and assess performance and operation based on those weight increase enhancements (installing armoring plates which adds 30-40% to the hulls weight
N13	Ability to distinguish between scrapping, upgrading and refitting existing hulls from feasibility perspective
N14	The ability to redistribute weights, systems, engines and change propulsion packages and ensure that these fittings do not negatively affect the hulls operation speeds and sea keeping
N15	ensure that slow speed stability and sudden loads at one side of the boat for boarding missions does not sacrifice the safety of the mission
N16	Third party auditing and aid in elevating operational and engineering parameters (consultations)
N17	Collision and ramming impact on vessel hulls for intended or accidental impacts during operation assessments

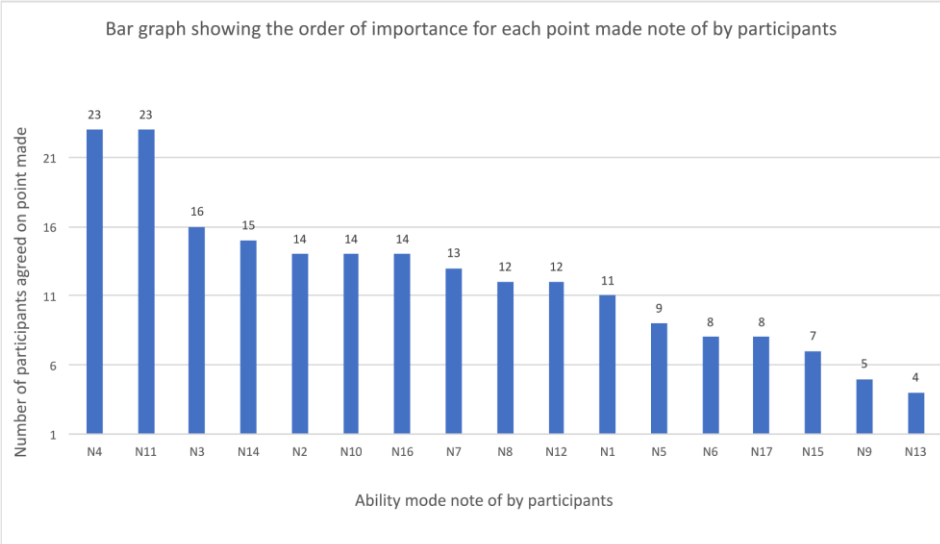

Fig. 3: A bar graph showing effective representation on the importance of each highlighted ability category mentioned in the interviews.

The answers for the questionnaire along with the overall operation requirements were assessed for the given vessels' categories. Similarities were drawn between the various responses given by these specialists and a conclusion of the findings guided the study towards three components.

A lot of towing tanks all over the world get enhanced to deal with developing and studying large waves hance large wave making capacity, however, the maximum projected sea state within the given parameters of the assessment was sea state 3, and the general recommendation was to build the facility to a sea state 4 wave making capability since future hull developments might require operation in areas of the Mediterranean sea, Red sea and the Arabian Gulf with normal sea states reaching 3.5. The towing tank length proposed in these interviews was 100 to 200 meters in length, a width of 4 to 6 meters, a depth of 3 meters and with a carriage speed of 4 to 7+ m/s. Even if the outcomes of the questionnaire were focused on shallow territorial waters, a 3-metre towing tank assumption was suggested to reach a low Froude depth number during high speeds.

3. RESULTS

The ability to assess the hydrodynamic performance of a range of vessels that can operate at relatively high speeds up to 40 knots and in relatively low sea states (Arab's coastal region). Due to the relatively short vessel lengths and high-end speed capability (resulting in very high length Froude numbers, which is speed/length ratio and could provide corresponding ship models' speed to a known full-scale hull), it is concluded that such a capability must include both experimental and numerical components.

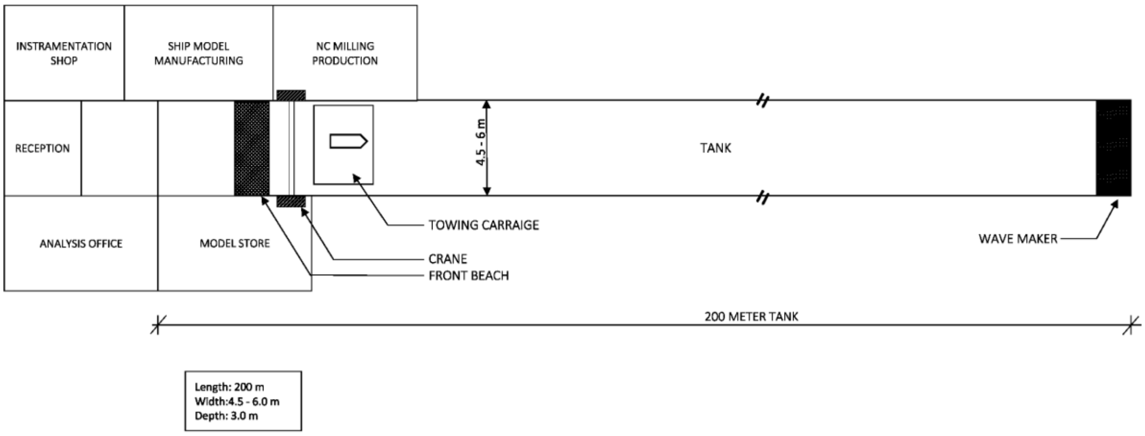

Fig. 4: Projected general layout of the Arab's hydrodynamic facility.

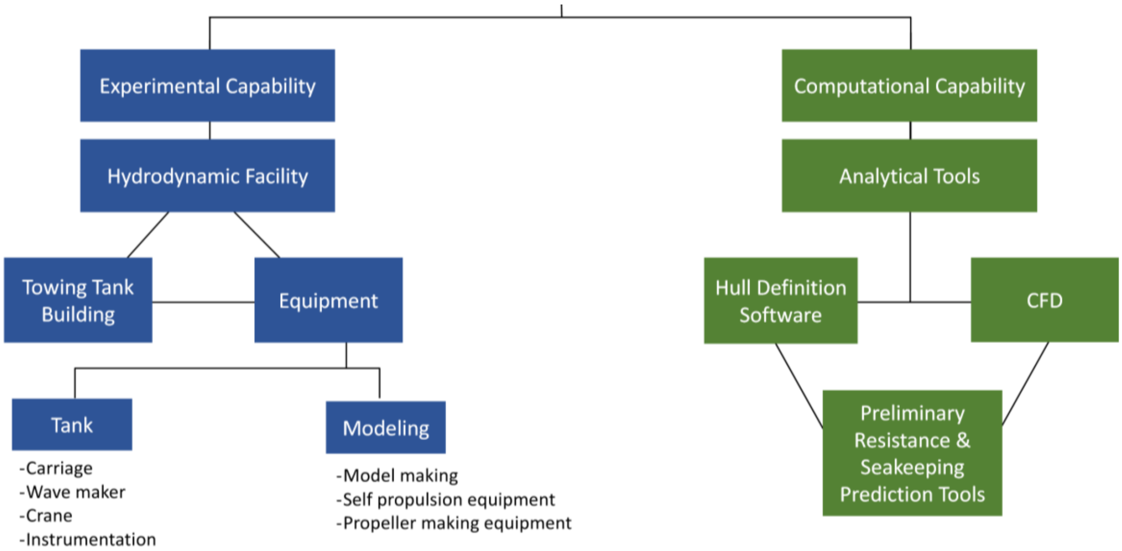

Fig. 5: Breakdown of the Key Facility, equipment, and analytical tool components to develop a hydrodynamic capability.

Such operations are considered to be generally beyond the level of confidence currently provided by numerical methods alone. Thus, it is highly recommended that a dedicated experimental facility, in the form of a high-speed towing tank, become the 'flagship' of the hydrodynamic capability. Based on the outcomes of questionnaires to groups A and B, a required facility with the following parameters are shown in Fig. 4.

As part of the study, a review of a large number of existing Towing Tanks was performed. This was aided by a list of such facilities compiled by the International Towing Tank Conference (ITTC, 2017). It was found that only a small percentage of existing facilities were geared to handle the high speed and/or small craft that is the focus of this study, as an added capability to the Arab's navies to design and build their own high-speed patrol boats. Further investigations involved direct discussions with staff from existing Towing Tank facilities (Turnock, 2017; Macfarlane, 2017) and providers of key equipment (Ross, 2017; Tiedeman, 2017). Following this investigation and discussions it is recommended that a Towing Tank of the approximate dimensions shown in Fig. 4 be developed, with key facility equipment and analytical components as shown in Fig. 5. Since the recommended facility is assumed to be built in a governmental agency, land around the towing tank will be government owned; hence, no need to incorporate land purchase costs into the assessment. The required numerical and experimental tools with updated pricing are summarised in Tables 2 and 3.

Table 2: Hydrodynamic Essential Numerical Tools:

Analytical Tool	**Example**	**Price Range (USD)**	**Yearly renewal Fees (USD)**
CFD	**STAR CCM+**	20,000	20,000
Hull definition software, including preliminary resistance and seakeeping predictions tools	MAXSURF	8,800	8,800
Preliminary resistance and seakeeping prediction tools	MAXSURF	1,500 to 3,500	1,500

Table 3: Hydrodynamic Essential Experimental Tools:

Category	**Component**	**Description**	**Pricing Range**
Towing tank	**Carriage**	Fully installed hydrodynamic laboratory ship model testing carriage for a towing tank 6m in width and 200 m in length. Speeds up to 12 m/s and max acceleration and deceleration :1 m/s^2 Emergency braking deceleration: 3 m/s^2 Carriage control system and operators test station that are designed for mounting various dynos and instrumentation.	1.66 to 2.7 million USD
	Rails	Fully installed 200 metre rails for high speed carriage with alignment and levelling sleepers, buffers and braking system and rail gauge (centre between rails): 6.8 m	1.26 to 2.14 Million USD
	Resistance Dynamometer	Resistance dynamometer and pneumatically operated model clamp for measuring the resistance of ship models which are being towed by carriage. Also used during propulsion tests with ship models for applying force in addition to the propeller thrust when required. The ship model is towed by way of a coupling rod which can freely adjust in 3 planes. The transducer range rated load is 100 to 500N that includes a resistance dynamometer for the measurement of resistance and alteration of draught and trim during tests of relatively small ship models of up to 3m on smooth water and in waves. Stainless Steel Towpost suitable for larger models upto 5m in length and Calibration Devices excluding weights. Guiding arms and equipment designed for the measurement of changes to Trim / Draught of ship models during resistance and propulsion tests.	390,000 to 660,000 USD

	Open-water propeller dynamometer	Electric open water dynamometer for use in towing tanks with streamlined watertight casing to standard height 630mm for use in ship model towing tanks. Equipped with support tube and equipment for measuring the traverse forces action on the bearing at the shaft end of the shaft. Is to also include stern tubes and extra weights.	250, 000 to 425, 000 USD
	Ship model Self propulsion dynamometer	Ship model Propeller Dynamometer for carrying out propulsion tests with ship models of a wide range of sizes. Rated Max Torque ±10Nm, Rated max Thrust ±250N at 3500rpm. Ship model Propeller Dynamometer for carrying out propulsion tests with ship models of a wide range of sizes. Rated Max Torque ±4Nm, Rated max Thrust ±100N at 3500rpm. Equipped with elastic coupling with support, shafts and bearings and stern tube assembly support brackets and static calibration device.	70,000 to 120,000 USD
	Self Propulsion Drive System	Self propulsion drive system with drive shafts and mounting kits. AC Self-propulsion drive motor with model mounting brackets, integrated encoder for speed feedback control. Type: AC Brushless Servo Motor.	60,000 to 100,000 USD
	Wave maker	Fully installed wet back hinged flap type irregular wave maker generating waves 300 mm high and frequency of wave 0.5 – 5 seconds.	420,000 to 720,000 USD
	Crane	12 metre extension arm pal finger 4 ton knuckle boom crane.	50,000 to 100,000 USD
	Beaches	6 m parabolic wave absorbing beach with movable centre.	165,000 to 280,000 USD
Modelling Equipment	**Ship Models**	Various vessel and hull models ranging 2 – 4 m in length with single screw and twin screw propeller shafts.	130,000 to 220,000 USD
	Propeller models	5 model propellers suitable for use with the ship models.	90,000 to 150,000 USD
	Model making, Propeller making	Various technical workshop model making machinery and tools including a numeric control model making machine and consumables	350,000 to 700,000 USD
	Self-propulsion	Self propulsion drive system, with drive motors, drive motor speed encoder rack and counter, drive shafts, cabling and drive system control.	60,000 to 100,000USD
Final budgetary estimation range for experimental tools			**4,955,000 to 8,423,500 USD**

Specialities and experiences vary when structuring the required staff to operate a hydrodynamic facility. A breakdown of the typical staff required to develop the hydrodynamic capability can be seen in Fig. 6.

To operate a hydrodynamic facility various roles and specialties with varying salary ranges are required to achieve the desired experimentation and analysis investigations required to elevate fleet hydrodynamic capability. Table 4 shows the breakdown of the required staff based on minimum number required per specialty and the yearly salary range per specially.

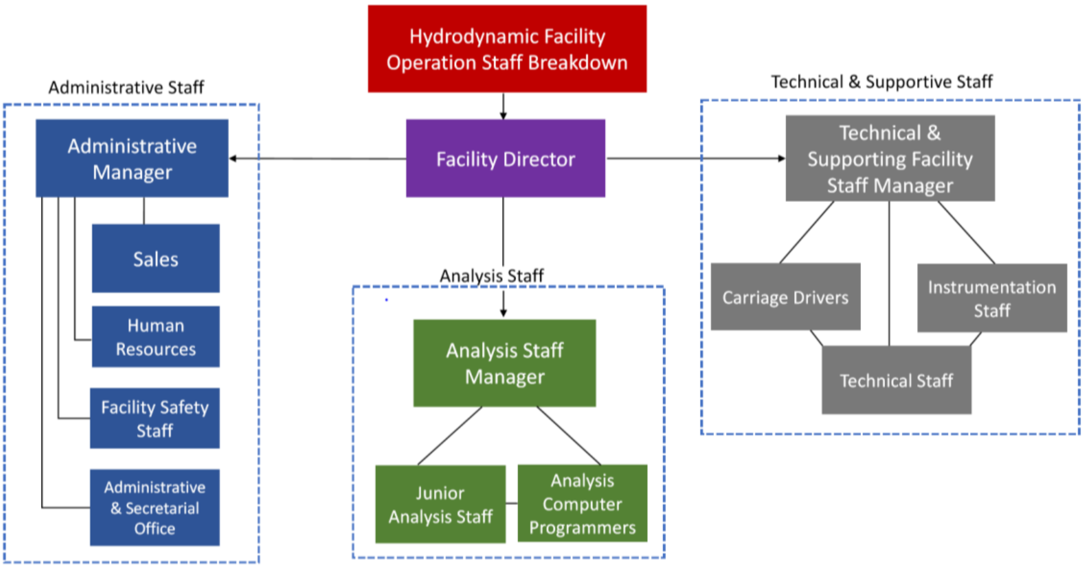

Fig. 6: Hydrodynamic facility staff breakdown.

Table 4: Summary of the required staff and corresponding budget to operate a towing tank:

Department	**Specialty / Job title**	**Number required**	**Yearly salary range per member (USD)**	**Yearly salary range per team (USD)**
Director	Facility Director	1	210,000 – 275,000	
Analysis Staff	Analysis Staff Manager	1	150,000 – 210,000	
	Junior Analysis Staff	3	150,000 – 210,000	450,000 – 630,000
	Analysis Computer Programmer	2	150,000 – 210,000	300,000 – 420,000
Technical & Supporting Staff	Technical & Supporting Facility Staff Manager	1	150,000 – 210,000	
	Carriage Drivers	2	120,000 – 150,000	240,000 – 300,000
	Technical Staff	2	120,000 – 150,000	120,000 – 150,000
	Instrumentation Staff	2	120,000 – 150,000	120,000 – 150,000

The varying experience and skill levels required to construct the hydrodynamic facility operation staff can be better explained in table 5. A percentage representation of the staff operation costs percentage to operate the hydrodynamic capability as per specialty is shown in Fig. 7.

Table 5: A brief of hydrodynamic facility departments, staff roles, numbers and salary ranges:

Department	Role	Role Description
Director	• Facility Director	A highly experienced hydrodynamicist with 20 – 30 years experience in managing hydrodynamic facilities. At the beginning of the project He will be acting as a consultant to setup and establish the procurement parameters for the tender and will be working on recruiting staff and leading the team. A person with vast knowledge in defence projects and costal operation security projects for vessels meeting parameters of table 1.
R & D	• Analysis Staff Manager	A Ph.D. senior staff analysis manager with 10 – 15 years' experience in managing and conducting analysis. Will be recruited by the facility director.
	• Junior Analysis Staff	Three junior staff that hold a naval architecture and/or marine engineering degrees with 5 years experience in CFD, STAR CCM, MAXSURF and other analysis software. At later stages these staff will be replaced by the Arab Ph.D holders upon finishing training and being incorporated into to operation of the facility.
	• Analysis Computer Programmer	Two computer programmers with 5 years experience to conduct basic codding are to be recruited and incorporated into the analytical staff by the facility manager towards the end of the 4th year of the project.
Technical & supporting staff	• Technical & Supporting Facility Staff Manager	A professional staff member with an Masters degree and a minimum of 15 years experience in conducting supporting facility tasks to the towing tank. He will be in charge of fitting the machinery and carrying handover training for Arab professional staff recruits to operate the facility.
	• Carriage Drivers	Two carriage drivers to be recruited by facility director.
	• Technical Staff	Two technical staff to conduct modelling and modifications to models. At later stages the technical staff manager will train and handover modelling tasks to Arab nationals to conduct these tasks.
	• Instrumentation Staff	Two instrumentation staff that conduct maintain of equipment. Arab instrumentation staff member can conduct that task whilst supervising maintenance by third party outsourced contract at later stages.

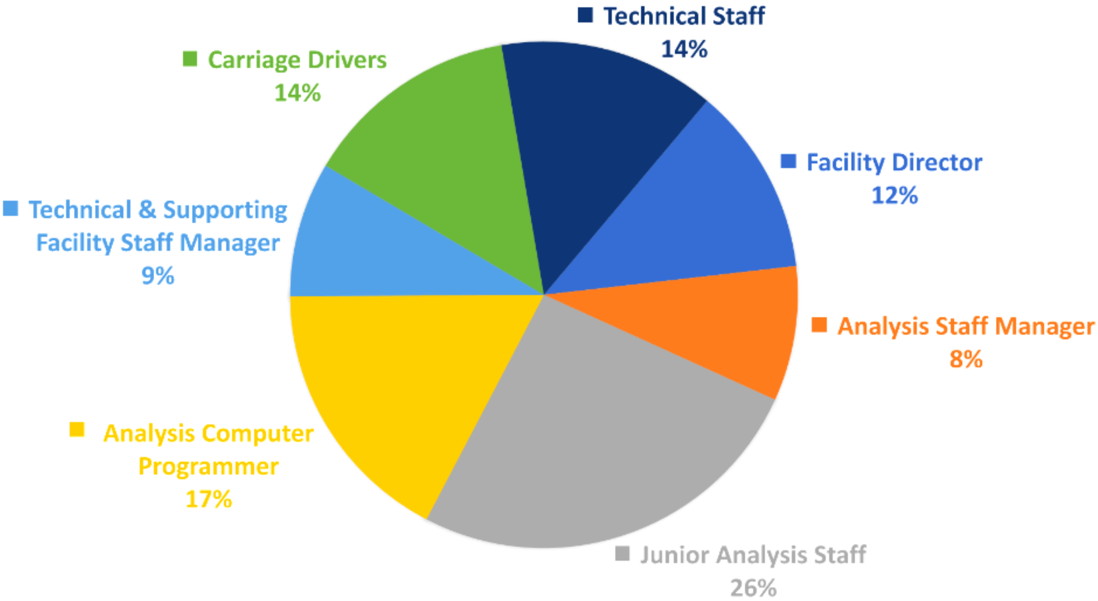

Fig. 7: Chart showing the Staff operation Cost Percentage per Specialty relative to the projected yearly staff operation cost range 1,600,000 – 2,100,000 USD.

Due to factors such as currency differences, inflation due to duration of project and variation in the Arab's countries tendering process, the overall project parameters were all multiplied by a factor of 2.5. This is because the overall parameters of the projected operating and installation costs might encounter increases; hence the standard tendering practice to build the budgets with a multiplication factor of 2.5 to the estimated costs of all areas as shown in table 6. As can be seen the projected building cost is expected to range from 7 to 12 million USD. The experimentation tools cost is expected to range from 4.955 to 8.432 million, while the annual operating costs, including staff and ongoing equipment maintenance and licencing cost, is expected to be in the order of 1.6 to 2.1 million USD and 51,500 to 83,500 USD respectively. As noted, this incorporate any other expenses to optimize the facility operation parameters.

Other factors such as additional supportive staff, travel, conferences, maintenance costs or the deviations of recruiting of various operation staff have not been included since they are not significant to the change in the overall pricing margin and acquainted for with the 2.5 multiplying factor for deviations. Training costs for personnel to obtain PhD over a 4 year period was also not looked into. After studying the various parameters of developing the hydrodynamic capability and its key components, an implementation plan was drawn over 5 years projected period, as presented in Table 7.

The first step in developing the ability is to begin by 6 months recruiting and hiring period, for the facility manager who will also act as a consultant. The manager will employ staff to aid in constructing the tender and tailoring the procurement process over the next 6 months.

Table 6: Projected Final Installation and Operation Costs

Category		Projected Price Range (USD)	Price range X 2.5 factor	Comments
Construction	**Land**	The land value factor was not accounted for in this study.		
	Building	7 - 12 million	17.5 - 30 million	The building price varies based on labour cost and material costs, however an average estimation was calculated, as per the international market and reviewers' feedback.
Equipment	**Experimental Tools**	4,955,000 - 8,423,500	Both the experimentation and analysis tools were calculated with the projected yearly increase of price data (inflation rate) and expected increase range of price; hence, these components of the study were not accounted for in the 2.5 factor.	
	Analysis tools	51,500 - 83,500		
Projected Final Installation Cost			**22.5 – 38.5 million USD**	
Projected final yearly staff and operation cost once facility is fully operational			**1.6 – 2.1 million USD**	

Table 7: Projected budget 2023 - 2028

Year	**Projected Budget Breakdown (USD)**		**Overall Yearly Budget Projection (USD)**
2023	6 months facility director salary	110,000 – 137,500	110,000 – 137,500
2024	12 months facility director salary	210,000 – 275,000	6,960,000 – 11,825,000
	30% payment of tender	6,750,000 – 11,550,000	
2025	12 months facility director salary	210,000 – 275,000	210,000 – 275,000
2026	12 months facility director salary	210,000 – 275,000	510,000 – 695,000
	12 months analysis manager salary	150,000 – 210,000	
	12 months technical manager salary	150,000 – 210,000	
2027	Full Staff salary	1,600,000 – 2,100,000	1,600,000 – 2,100,000
2028	Full Staff Salary	1,600,000 – 2,100,000	17,350,000 – 29,050,000
	70% Final payment	15,750,000–26,950,000	

By the beginning of the second year a tender could be issued for a 6-month period and shall be an all-inclusive tender to build the facility and install all required components within a 30-month period. Software and electronic components of the tender could be delayed till the last part of the installation process to ensure that by the handover period the components did not age. During the first 6 months of the implementation plan a total of 2 – 4 hydrodynamic PhD students, either civilians or members of the Arab natives get sent to conduct PhD studied/ training to enable them to be incorporated into the facility operation within the 4th and 5th years of implementation. Towards the end of the third year and for a 12-month period the analysis staff manager will be recruited and will go on to recruit the operational staff.

A technical staff then could be recruited towards the last year of the implementation and will conduct assessments on available technical staff available and train them in the required tasks. The last 12 months of the implementation plan will involve trial operation and handover training from the contracting party. Based on the proposed hydrodynamic capability implementation plan, a yearly breakdown of the budget between 2023 – 2028 is calculated.

4. CONCLUSIONS

In conclusion, the data gathered and analysed from the qualitative questionnaire provides necessary information to identify the key parameters required to elevate the Arab's hydrodynamic capabilities as the fleet would significantly increase throughout the coming decades. The need for elevating the Arab maritime sector's hydrodynamic capabilities has been identified by the assessment and findings of this paper. The ability to assess the hydrodynamic performance for a range of vessels that operate at relatively medium to high speed up to 40 knots and in relatively low sea states (from calm water up to the top of sea state 3) generated the capability design parameter.

Based on the outcome of the interviews conducted and the assessment of the data findings, the key abilities, parameters and technical requirements to develop the required hydrodynamic capability were investigated. The experimental capability should be complemented by a numerical capability. It is estimated that the total cost to develop and implement this capability is 22.5 to 38.5 million USD, followed by an annual projected operational cost (once facility is fully operational) of 1.6 – 2.1 million USD.

A yearly projected operation projected final yearly staff and salary cost once facility is fully operational of 1.6 – 2.1 million USD is estimated.

A 5-year plan to implement the parameters of this capability along with its, components, and operation staff will enable the Arab countries and the region to enhance its projected fleet outlook for the upcoming operational challenges in its future.

5. FURTHER WORK

A feasibility study addressing financial analysis and market attractiveness assessments and a towing tank operation competition study can be conducted if the hydrodynamic facility will operate for profits to overlap defence and commercial operations.

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MODELLING AND SIMULATION COMPARISON OF CONVENTIONAL AND INNOVATIVE TRANSPORT FOR NATURAL GAS

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Keywords: Natural gas, CNG, Airship, Agent-based Simulation, Modelling, anyLogistix™.

1. ABSTRACT: Nowadays, technology is still heavily dependent on fossil fuels, especially natural gas. Within the last century, the production and consumption of this resource increased decade by decade, using new technologies to increase profits and decrease the costs linked to production and transport. This paper aims to compare two already existing solutions for transporting natural gas, which have a high impact on the environment, with a prototype technology that will soon be available for commercial and industrial use: the airship. The research started by collecting data from previous studies and calculating the parameters needed to determine the cost of the two scenarios considered: one as a system pipeline+compressed natural gas (CNG) carrier, the second as an airship directly delivering the natural gas. The two scenarios have been then simulated in Anylogistix and modelled to examine the profits given the hypothetical but equal demand for natural gas transported by the pipeline+CNG carrier system and by airship. The simulation output has a present slight tendency of choosing the first system for CNG transport due to the careful optimisation of this system which, in real case studies, would not occur.

2. INTRODUCTION

Natural gas can be found in reservoirs all around the Planet. It can be found on top of oil deposits, in which we would find a superficial layer of natural gas, or in natural gas reservoirs in a range between 2 and 6 km from the surface (both from the surface and the seabed). Given the location of the deposit locations, the extraction process is neither simple nor economic. The difficulties linked to the natural gas deposits are the presence of shale, the extraction of tight gas (available only by fracking and acidizing of rock formations), the location of certain reservoirs in geopressured zones and the hazardous release of methane hydrates [1].

Once the deposit has been found and the cost-benefit analyses declared profitable for the extraction, the production wells are drilled above the deposit and the production site is established.

Independently by the extraction method employed, natural gas must be transported to the consumers. In general, natural gas does not get extracted and given directly to consumers, but it goes through several processes to be safely transported. For example, in the case of maritime transport, it could go under different processes in case it should be transported at a liquified (LNG) or a compressed (CNG) state.

To continue the previous studies done by our department, this paper faces an initial approach to the definition of a new means of transport for natural gas. The employment of airships for the transport of CNG will be compared with a traditional transport system composed of a pipeline.

Existing solutions for transporting natural gas have a high impact on the environment. LNG requires the construction of specific facilities for the liquefaction and regasification processes. Meanwhile, CNG does not require such measures, but specialized equipment for the compression and expansion processes with a low harmful impact than LNG. Natural gas can be carried in its gaseous form as the payload of airships. At certain conditions of temperature and pressure, the specific characteristics of the gas are equivalent to the ones of air. The presented research aims to compare the transport of natural gas through a pipeline and a CNG carrier, and by airship.

This paper will not focus on the extraction process of natural gas from the well. We have performed calculations regarding the exit pressure from the well, which will be necessary for different considerations in the two scenarios. We have not considered the costs related to the energy losses due to the extraction tree being common to the two scenarios.

To simulate transportation time and cost we used AnyLogistix Software. Two scenarios were considered:

- Pipeline scenario: from the well the gas is transported at a pressure of 40 bar through a pipeline to the Harbour where it will be loaded on a CNG transport ship at a pressure of 250 bar. The payload will be transported to the distribution centre (DC) that we placed in Japan and then arrive at the consumer through a second pipeline.
- Airship scenario: form the well the gas is transported at a pressure of 1,4 bar on an airship directly to the DC in Japan and then arrives directly to the consumer.

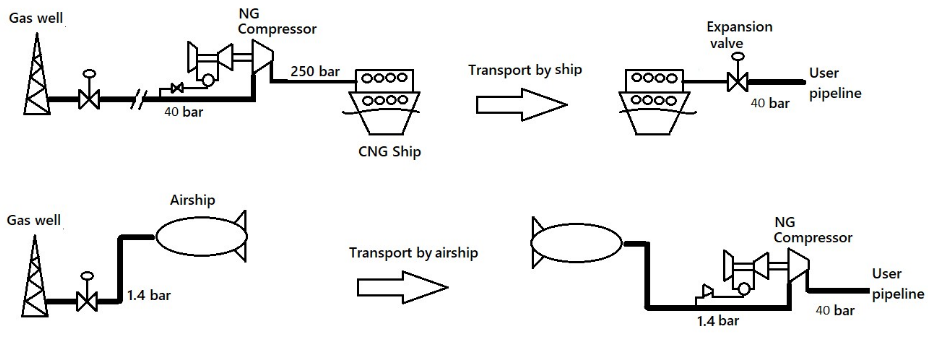

Figure 1: Scenarios model : pipeline + CNG carrier (above); airship (below)

For safety and practical reasons, we have considered the transport of compressed natural gas and not LNG. This is because of the more practical sites which will be developed, avoiding problems related to the liquefied and regasification processes. Another initial constraint is the position of the unspecified well which will be on land and for the deposit parameters we will consider the approximations of existing wells that can be found in the literature.

3. MATERIALS AND METHODS

3.1 Pressure

To develop the model, it is necessary to compute the changes in gas transport under different conditions of pressure. several methodologies are available. The first method is the approximation for which 10 meters of depth corresponds to a variation of pressure of 1 bar from the atmospheric one. Knowing that natural gas is compressible, this first approximation would not be correct because it employs hydrostatic calculations. As proposed by [2] we can apply a derivative of the ideal gas law with all the considerations of the authors about the gas conditions to find a more precise pressure of exit of the flow from the well:

(1)
$$p_w = p_0 \exp\left(\frac{Mg(h-h_0)}{ZRT_{avg}}\right)$$

Where:

- p_w and h are the exit pressure and the depth for the well;
- p_0 and h_0 are the data for the reference point (in our case 101,325 Pa and 0 m);
- M is the molecular mass of the considered gas, in the case of methane it will be 16.04 g/mol;
- g is the gravitational acceleration;
- Z is the compressibility factor, in the case of methane is about 1 at the reference point;
- R is the ideal gas constant 8.314462 J/(K*mol);
- $T_{avg} = \frac{T+T_0}{2}$ which is the average absolute temperature.

Applying this formula, we obtain the pressure at the exit from the well and this information will be used to calculate the flow rate of the gas in the pipeline. With the data collected, we found that the exit pressure from our well is around 4 MPa.

3.2 Pipeline

The research focuses on the comparison of two scenarios for the transport of natural gas from a well to a consumer. To compare we then must build a cost analysis of the two scenarios. For the pipeline scenario, we must consider the cost related to it. The estimation will be calculated proportionally to its length and diameter.

Pipelines have been, until now, the best mean of transport for hydrocarbon shipping under several circumstances (from an energy efficiency point of view, up to environmental considerations) [3;4]. The costs depend on many factors [5] including the location of the pipeline, in an urban or a rural area. Parker [6] proposed detailed research on the logistics of building a pipeline keeping the focus on the length and diameter parameters. The considerations done are very general and give us a general idea of the concepts to take into consideration. The final formula that we will use to approximate the total cost will consider four main sources of cost: cost of materials, of labour, the miscellaneous costs, and the right of way cost:

$$Cost\ (D,L) = Material\ Cost(D,L) + Labour\ Cost(D,L) + Miscellaneous\ Cost(D,L) + Right\ of\ Way\ Cost\ (D,L)$$
$$= \{\ [330{,}5\ D^2 + 687D + 26960]L + 35000\} + \{[343D^2 + 2704D + 170013]L + 185000\}$$
$$+ \{[8417D + 7324]L + 95000\} + \{[577D^2 + 29788]L + 40000\} \quad (2)$$

where *D* is in inches, *L* in miles and *Cost* in dollars. Once obtained the total cost, it is possible to make the approximation in every currency.

This research was followed by Knoope [7] which provided insight into 2 different ways to determine the cost of a pipeline, considering not only the diameter but also the mass flow passing through it. By considering it as fluid CO_2, the authors provided a detailed analysis of different studies, determining cost ranges for diameter variating from 0.11-0.64 M€2010/km for 0.3 m of diameters and 1.5-13M€2010/km for 1.3 m.

Certain considerations must be done initially. The Handbook for the transportation and distribution of gas [8], proposes the following assumptions: the number of compressor stations is known; the considered layout is horizontal; and the flow rate along the pipeline is constant. The costs of the pipeline for each trip can then be calculated considering the pressure and the temperature at which the gas will be inside the pipeline, deciding on a nominal diameter and calculating, supposedly a hypothetical length, every how many kilometres (or miles) should a compressor be placed to avoid a too high loss of pressure. Once this number is calculated, it is possible to determine the losses of flow to feed the compressors and so the approximate cost of each trip to load the CNG carrier.

The specific data of the pipe considered have been:

- The pressure inside the pipeline of 40 bar (constant);
- Length of 800 km;
- 40 compressors placed every 20 km between which a loss of 10 bar is registered;
- A temperature inside the pipeline of -25°C (248.15 K);
- A flow speed of 10 m/s;
- Nominal diameter of 0.5 m;
- A viscosity of 20*10-6 m2/s;
- The efficiency of the compressors of 0,85 and of the turbo gas needed to feed the compressors of 0.35;
- A lower heating value of 50*106 J/kg.

3.3 CNG transportation

The maritime transport considered in the scenario is a cargo ship for CNG. The technology used to develop this specific type of cargo ship has been studied since the 1960s, always being categorised as too expensive for the final means. Back in the early 2000s, Wagner [9] studied the reignition of the maritime industry towards CNG carriers. The idea behind this research was to provide a view of the evolution of the needed technologies to avoid the costs related to LNG transportation. Compared with LNG carriers, the advantages of CNG carriers increased little by little since the first studies.

For the first decade of the 2000s, there is a record of many studies [10-12] on the progressive state of the art, describing step by step the evolution of maritime carriers. With the advantages of CNG carriers, also the limitations started to be clearer, such as the lower amount of payload. In general, there were already ideas on the possible technologies which could be used, as much as the possibility of employing new technologies, such as go-to-market (GTM) vessels (composite reinforced vessels mainly used for truck transport until then). This technology has been studied by several researchers [13-16], and the possibility of transporting for short distances high volumes of CNG was clear. Initial approximations resulted in half of the energy required for LNG carriers, with the possibility of adjusting the system with different numbers of ships according to the demand and representing a safe investment. For how much CNG used to present challenges in terms of technology and non-existent regulations, they were studied with also the development of prototypes to allow companies to invest in tested projects. Over the years, the technical challenges, the issues related to safety, reliability and risks have been tested and consolidated, allowing the building of many CNG carriers with similar characteristics. In general, nowadays, it is possible to carry by sea from 5 to 20 million nm^3 of CNG per trip at an average pressure of 250 bar (with certain exceptions, for example, the "VOTRANS" carrier) [17]. Given the data collected, the following data were chosen for the study:

- Engines power of 30 MW;
- The efficiency of the engines of 0.45;
- Speed of 13 m/s (40 knots).

For the volume consideration, we considered the exit volume from the pipeline to properly balance our model in the simulation.

3.4 Airship

Nowadays many prototypes of airship carriers have been studied and developed, but with a relatively small production due to the costs, the advancement of technology or also the failure of previous prototypes. Continuing in the direction of the previous research of our university, we considered the characteristics and the data collected and obtained by [18]. From a structural point of view, the characteristics of different airships used in the fields of transport were considered [19-23]. The main idea is to consider a high-volume vehicle (from tot volume to tot volume) and the hypothesis of using a ratio of Hydrogen to natural gas of 40%/60%. The choice of hydrogen as lifting gas was done considering the characteristics of both the lifting gas and the transported gas. Given the high inflammability of both gases, the choice of a cheaper lifting gas was done compared to the choice of helium.

Among all the possible choices of airships (considering it as a prolate spheroid), we considered the technical characteristics of:

- The volume of 75000 m3;
- Speed of 120 km/h (33.4 m/s);
- c (major semi-axis) of about 54 m and a (minor semi-axis) around 18 m (a=c/3);
- Transporting a volume of natural gas at ambient temperature at which the methane has the same density as the air, and then it will not influence the balancing for the lift;
- Drag coefficient of 0.022;

4. SIMULATION

To develop the model and study the simulation of our scenarios an agent-based simulation was used. AnyLogistix software was chosen to analyze the performance of the theorized system of the gas transportation supply chain. It allows one to analyze and optimize the supply chain as well as to study the dynamic form of a system. To define our system as accurately as possible, preliminary calculations were developed in Mathcad to get the basic information. Such calculations considered data analyzed from several articles describing already existing systems.

4.1 Calculations

To calculate the pipeline diameter, we chose the average output of Gas flow rate $Q'_{wellhead}$. [1]. The wellhead pressure of p = 4MPa and the average temperature $T_{wellhead}$= 348.15 K [24.].

The mass flow rate at the wellhead was calculated by the formula:

(3) $$m'_{wellhead} := \rho_{wellhead} \cdot Q_{well}'$$

where $\rho_{wellhead}=p/(R'T_{wellhead})$ is the gas density, and R' is the gas constant relative to the CH_4.

For our case, we consider natural gas as the ideal liquid containing only methane gas:

(4) $$\rho_{wellhead} := \frac{p}{R' \cdot T_{wellhead}} = 22.11 \frac{kg}{m^3}$$

The density at -25°C, the transportation temperature [25] will be:

(5) $$\rho_{pipeline} := \frac{p}{R' \cdot T_{pipeline}} = 31.019 \frac{kg}{m^3}$$

This information can be used to calculate the flow rate inside the pipeline:

(6) $$m'_{wellhead} := \rho_{wellhead} \cdot Q_{well}' = 3.838 \frac{kg}{s}$$

The mass flow rate in the outlet of the wellhead does not change, but the volumetric flow rate at the pipeline is changing along the pipeline according to the Temperature and Pressure changes.

The volumetric flow rate at the pipeline:

(7) $$Q'_{pipeline} := \frac{m'_{wellhead}}{\rho_{pipeline}} = 0.124 \frac{m^3}{s}$$

The diameter of the pipeline is determined by the standard for steel pipes for natural gas [26]. By considering also eventual surges, a nominal diameter of 0.5 m in L360 GA was chosen.

Following the abovementioned considerations, the pipeline was divided into sections to maintain a constant gas pressure with small pressure drops, which allowed us to calculate the required number of compressors for the safety of the system. In our model, we considered 40 compressors (one every 20 km). Between each compressor, a drop of 10 bars was registered. Each compressor is moved by a prime motor (e.g. an internal combustion engine which is fueled by the bleeding part of the natural gas flow rate from the pipeline. Therefore, we considered the following calculation to determine the flow of exit from the pipeline:

(8) $$m'\_final_{afterbleeding} := m'_{afterbleeding} - m'_{CH4\_TG} \cdot n_{compressors} = 3.42 \frac{kg}{s}$$

In particular, each compressor contributed to a loss of 0.1 kg/s from the initial flow.

It has also been possible to determine the power of each compressor. In particular, it was studied how the first compressor would have needed to have a power of 178.7 kW and the last one of 159.2 kW, leaving us to assume that the cost difference between each compressor will not be much, and so we will consider it nearly constant.

Given the exit flow from the pipeline, it was also possible to determine the final volume of natural gas, which would have been the one loaded on the CNG carrier. Considering the abovementioned data, we obtained that the total losses of natural gas from the CNG carrier would be around 123400 m^3.

Considering the information about the airship that we supposed, it was possible to calculate the necessary power of the engine of the airship and considering the efficiency of the engine (35%) and the propellers (70%), find how much of the initial volume of natural gas would have been consumed to propel the airship. In particular, considering the different densities of the pipeline scenario, an initial volume of 45000 m^3 corresponds to a final volume of natural gas at 1.4 bar of 37200 m^3.

Through all the collected data it was then possible to calculate the duration of the single trips for the airship scenario and the pipeline + CNG ship scenario, respectively 6 days and 18 days.

4.2 Model

Once the calculations were done, the data were used in a model to estimate the profits of using an airship as an alternative to CNG carrier transportation. The results and inputs are presented in Table 1.

Table 1. Simulation data

Parameters	*Value*	*Units of measure*
Customer pipeline demand	4 872 000	kg
Customer airship demand	158 000	kg
Lead Time Pipeline	18	days
Lead Time Airship	6	days
Selling price	2.08	$/kg
Cost Natural Gas 1.4 bar	0.1	$/kg
Cost Natural Gas 40 bar	0.7	$/kg
Shipping Type	Full Truck Load	-
Pipeline Capacity	123 400	m^3
CNG ship Capacity	123 400	m^3
Airship Capacity	45 000	m^3

Due to the constraints of AnyLogistix, it was not possible for us to directly simulate a pipeline. The structure we adopted for our model considered then the gas through the pipeline as the payload of a truck that will transport the whole column of gas in one trip.

The entities that we placed in our simulation model are the following:

- "Suppliers" are the wells located in Canada, British Columbia [27], from which the gas comes out at a flow rate of 3.85kg/s and with a pressure of 4 MPa to feed one the pipeline and one the airship. We suppose that the wells can always produce the amount of gas required to satisfy the demand.
- "Distribution centres" (DCs) are in two locations in Japan, one for the natural gas by airship and one for the natural gas carried by the CNG carrier.

- The "Factory" in Vancouver is used to compress the gas from 40 to 250 bar and for loading operation to the carrier. This operation in the model is not represented but it calculated the effect of the compression of the gas with different densities (comparison densities) and losses due to the compressors used along the pipeline and the natural gas used for the CNG carrier.
- The "Customers" define the needed demand from the two distribution centres.

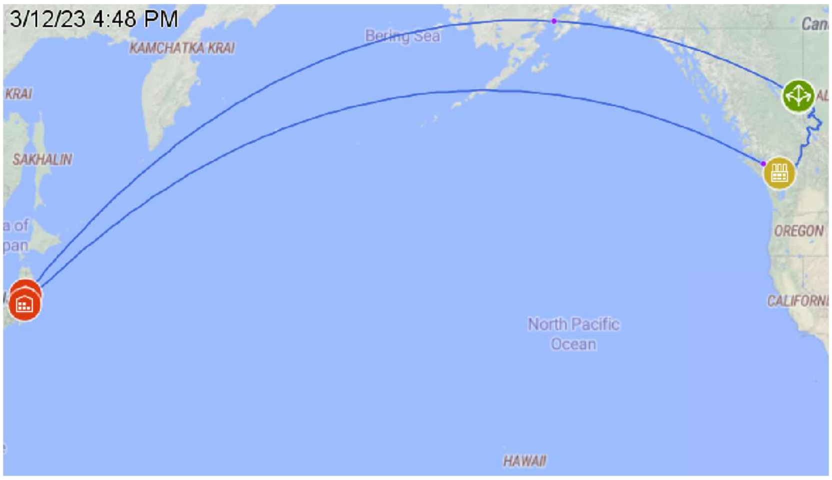

Figure 2: Actual behaviour of the two scenarios (in the figure it is possible to see the airship and the departing CNG carrier)

4.3 Results

The obtained results were calculated in a time range of one year (from the 1st of January 2023 to the 31st of December 2023). Figure 3 represents the Profit of the Pipeline scenario (green) and the Airship scenario (red).

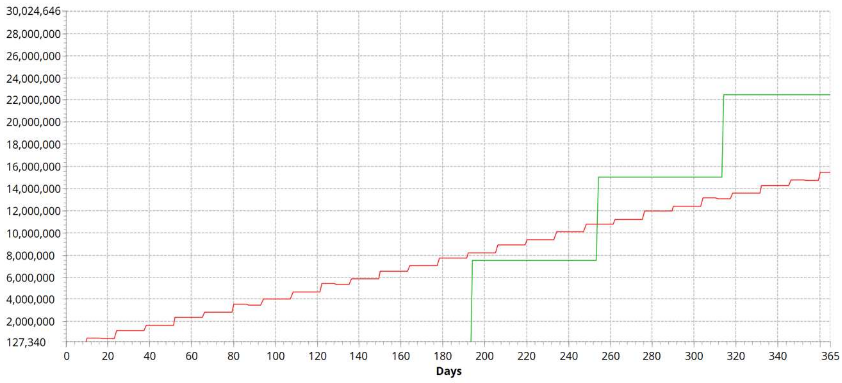

Figure 3: Daily profit: Pipeline scenario (green) and airship scenario (red)

As can be seen from the results, the pipeline and CNG carrier profit results are more than the profit given by the airship. These results may vary depending on more precise information on the costs of the involved structures (the harbour facility and the distribution centres). These results provide the idea of why at present time, given the reliability of airships as means of transport, this technology is not yet used. Moreover, we can notice the difference in the delay time between the two means of transport: while the pipeline has a greater delay than the one of the airship, because of the loading time of 11 days, on the long period it results in being a more reliable mean of transportation for natural gas in the considered system than the airship.

5. CONCLUSIONS

This research aimed at presenting the calculation and the simulation results of a model comparing two scenarios of transporting CNG from a well to customers. Using data found during the literature research, the well was decided to be considered in Canada and the final customers in Japan. With the appropriate considerations for the two scenarios, calculations were performed to retrieve as much precise as possible data for the description of the model. A model was then described in Anylogistix to compare the profits of the scenario employing a pipeline and a CNG carrier and the one considering the direct transport with an airship.

With the definition of the data and taking into account the constraints given by the case that was studied, we ended up finding as a result of the simulation, that the pipeline scenario resulted in being more profitable than the scenario employing the airship. We consider that a more attentive analysis of the costs should be performed and that the pipeline solution and the employment of a CNG carrier may result profitable, but in the long period, airships would start employing technology which would make obsolete the pipelines and the CNG carriers, due to the lower environmental impact and on the smaller costs in terms of maintenance and initial costs.

Future studies will focus on the improvement of such a model and a more accurate determination of the parameters of the pipeline, CNG carrier and airship to determine the losses and consumptions due to the different means of transport, considering different designs of airships which would improve the power needed by the propulsion system for the airship.

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Obtaining green warehouses from converting the potential energy of trucks into Piezoelectricity: A Conceptual Introduction.

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Keywords: Green Warehouse, Data, kinetic energy, Piezoelectricity and Green Energy.

1. ABSTRACT:

There is no doubt that the general trend in all countries of the world is the use of clean, renewable, and inexhaustible energy sources, no matter what happens, to preserve the environment by reducing emissions from fuels and at the same time preserving the existing stock of fuel for future generations. In addition, in the long run, the cost of renewable energy is more economical than the energy generated from fuels, and by extension, if clean energy is used in the fields of industry and transportation, it will have a very strong impact on the entire supply chain, whether service or production.

The research methodology is depending on reviewing the previous studies to get a theoretical framework linking between piezoelectric tiles and green warehouse so as to link piezoelectricity with obtaining green warehouses and to get a theoretical framework for the relationship among the dependent variable "Obtaining Green Warehouses" and the independent variable "piezoelectricity".

The research findings suggested a theoretical framework "The Research Model" to describe the research problem and define the research variables to show how they might relate to each other.

This research will be one of researches that links the idea of using kinetic energy through converting it into electrical energy with the concept of green warehouses.

2. INTRODUCTION

There is no doubt that the general trend in all countries of the world is the use of clean, renewable, and inexhaustible energy sources, no matter what happens, to preserve the environment by reducing emissions from fuels and at the same time preserving the existing stock of fuel for future generations. In addition, in the long run, the cost of renewable energy is more economical than the energy generated from fuels, and by extension, if clean energy is used in the fields of industry and transportation, it will have a very strong impact on the entire supply chain, whether service or production. (Shahzad et al.,2015)

In this research, we highlight the technical potential and the economic feasibility of activating the conversion of kinetic energy, specifically the kinetic energy resulting from the movement of trucks and cranes. (Mike Hanlon, 2008).The possibility of converting it into electrical energy using piezoelectric techniques and the possibility of using this energy in factories, companies and warehouses and its effect on the supply chain in which clean energy will be included and transformed into a green supply chain that the world strives to achieve, as well as discussing the economic feasibility of its application in the long run and seeing whether it is saving or not. (Al-Yafeai et al., 2020).

As for how to obtain electrical energy from piezoelectric tiles, this is done through the crystal materials from which piezoelectric tiles are made, which are characterized by their characteristics that they convert kinetic energy into electrical energy through the phenomenon of compressive energy. (Raghu Chandra Garimella et al., 2015). The conversion of kinetic energy into electrical energy takes place through piezoelectric crystals through the following physical equations "The formula to convert kinetic energy (1/2mv^2) to electrical energy (Energy = P*t) is, 1/2 mv2 = p*t, where **m** is the mass of the object, **v** is the speed of the object, **P** is the power and t is the time". (Megha BR,2019)

This will be done by integrating piezoelectric techniques with green logistics. It will explain how to obtain green warehouses from the movement of trucks moving inside warehouses and passing on a specific type of transformer that forms a direct electrical field from the movement resulting from the truck and generating Electrical energy that lights the warehouses for a period that allows goods to be transported to and from the stores. In addition, a detailed feasibility study will be discussed about the cost of electricity consumed by the stores and the cost of converting kinetic energy into green electrical energy and is it economically feasible in the long run or not. (Safaei et al., 2019)

2.1 GREEN WAREHOUSE

A green warehouse is defined as the performance in which the use of energy used is reduced and sustainable energy is utilized in its various forms, thus reducing the amount of waste and emissions. Progress towards a more environmentally friendly warehouse can be measured in a tangible way by seeking building certificates that evaluate performance across measures which are often associated with environmental, social and governance (ESG) standards. (Ranpak,2022).

Green logistics plays an important role in a larger mission: moving the world towards a green economy. A green economy is focused on low carbon emissions, efficient resources, and socially inclusive. Benefits of a green economy include reduced pollution, improved energy, and resource efficiency, slowing biodiversity loss, and maintaining ecosystem services, The green warehouse is considered one of the most important green logistics practices. (Agility,2021).

2.2 KINETIC ENERGY AND ITS ADVANTAGES

Kinetic energy is a form of energy that an object or particle possesses due to its motion. If work which transfers energy is done on an object by applying a net force, the object accelerates and thus gains kinetic energy. Kinetic energy is the property of a moving object or particle and depends not only on its motion but also on its mass. (Britannica,2022)

Kinetic energy is the energy possessed by a body in its motion. Kinetic energy is transferred between objects and can be converted into another form of energy. And the advantages of kinetic energy for a better understanding are: It is renewable, It is unpolluted as nothing burns, Reliable as there are 2 tides per day, Cheap to run once built and Availability for being an abundant resource. (**MUNAALIISMAILX**,2014)

2.3 PIEZOELECTRICITY

Piezoelectricity literally translates as electricity because of pressure. word pesos Derived from the Greek word "piezin", which means to squeeze. Discovery Piezoelectricity was invented in 1880 by the sister duo of Pierre and Jacques Curie where they were He discovered that squeezing crystals, for example, generated electrical charges on the crystals The surface of these materials due to the direct effect of piezoelectricity. (A History of the Piezoelectric Effect,2019)

Piezoelectricity, the appearance of a positive electric charge on one side of certain non-conductive crystals and a negative charge on the opposite side when the crystals are subjected to mechanical stress. This effect is exploited in a variety of practical devices such as microphones, phonograph pickups, and wave filters in telephony systems. (Btitannica,2023)

3. METHODOLOGY

The research methodology is depending on reviewing the previous studies to get a theoretical framework linking between piezoelectric tiles and green warehouse to answer the following research questions:

a) What are the previous studies that link piezoelectricity with obtaining green warehouses?

b) Can we get a theoretical framework for the relationship between the dependent variable "Obtaining Green Warehouses" and the independent variable "piezoelectricity"?

To achieve the research methodology's first aim to obtain the theoretical framework, the previous studies were divided into three sections to explain how to reach the required frame.

3.1 CONVERTING KINETIC ENERGY INTO ELECTRICAL ENERGY

As published by (Arfken et al., 1984) It explains kinetic energy that Galileo discovered in 1638, and the beginning of the law of motion, which explains how to deduce the law of motion, how to convert energy from kinetic to static, and all the laws of motion that have been discovered over the ages and show that the law of kinetic energy which is: K=1\2 m *v^2 (Equation1)

k= kinetic energy, m= mass of body, v= velocity

Published paper by (Iswanto et al., 2018) and it aims to clarify how to extract electrical energy from the movement of feet on piezoelectric tiles and clarify the amount of energies resulting from one step on the piezoelectric slab and clarify the great savings that will result from the use of these tiles.

(Urroz-Montoya et al., 2019) had a scientific paper explained the framework and proposals for piezoelectricity and clarification of the meaning of piezo energy and its uses and how to use it in extracting electrical energy from piezo energy by clarifying the idea of making piezoelectric tiles and different uses of piezoelectric tiles.

A study focused on the use of piezoelectric cells in high-density projects in the construction of self-powered projects, and people would start producing energy from walking around the facility. This paper highlighted the importance of replacing ceramic and granite tiles with sustainable piezoelectric tiles, which will create a self-sufficient project by redesigning an interior space for public facilities. The floor tile design incorporating piezoelectric cells results in a useful amount of energy for the electrification of public facilities using the high visitor population density. The research began by analyzing projects that replaced regular tiles with piezoelectric tiles to understand the goals and limitations of using these sustainable building materials in Egyptian public utilities, this paper presented the types of piezoelectric tiles and their resulting floors as shown in table (1). (Madonna Makram Solban & Rania Rushdy Moussa, 2019)

Company	Tiles Size	Energy Produced	Price in US $	Life span by years
Waynergy Floor	40 x 40 cm	10 W per step	451.5	20
Sustainable Energy floor (SEF)	75 x 75cm <u>OR</u> 50 x 50 cm tile	Up to 30 watt of continuous output. Typical power output for continuous stepping by a person lies between 1 and 10W (average 7W)	1,693	20
Pavegen tiles	50 x 50 cm	5 W continuous power from footsteps	395	20
(EAPs) Electro-Active Polymers	Sheets	1W	-----	20
Sound Power	50 x 50 cm	0.1W per 2 steps	270.9	20
PZT ceramic (Lead Zirconate Titanate)	Manufacturing in a small size	0.0084 W	36.1	20
Parquet PVDF layers	Layers	0.0021 W per pulse with loads of about 70 kg	-------	20
Drum Harvesters - Piezo buzzer Piezoelectric Ceramics	Vary	Around 0.002463 W	56.4	20

Table (1) types of piezoelectric tiles

And the following figures show the different shape of tiles in market, figure (1) shows different type of SEF piezoelectric tiles which are explained in table (1), and figure (2) shows the inner materials of piezoelectric tiles.

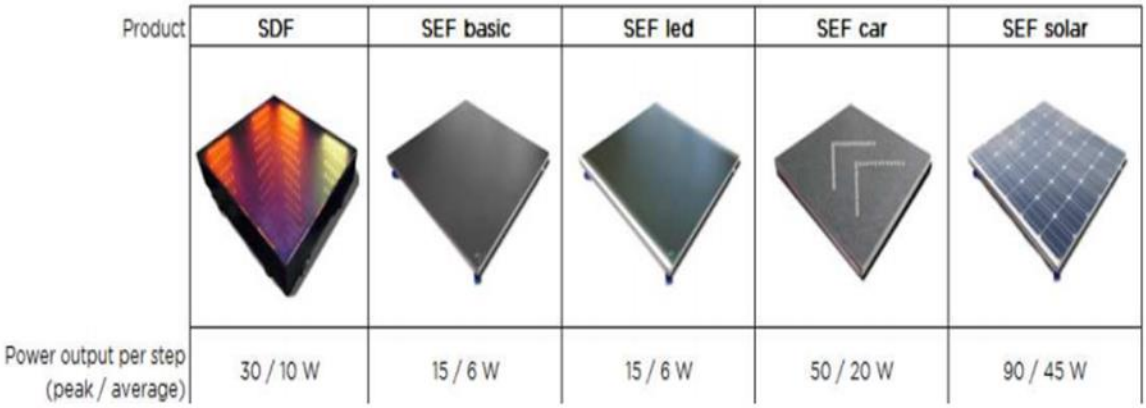

Figure (1) (SEF) tiles (www.rdso.indianrailways.gov)

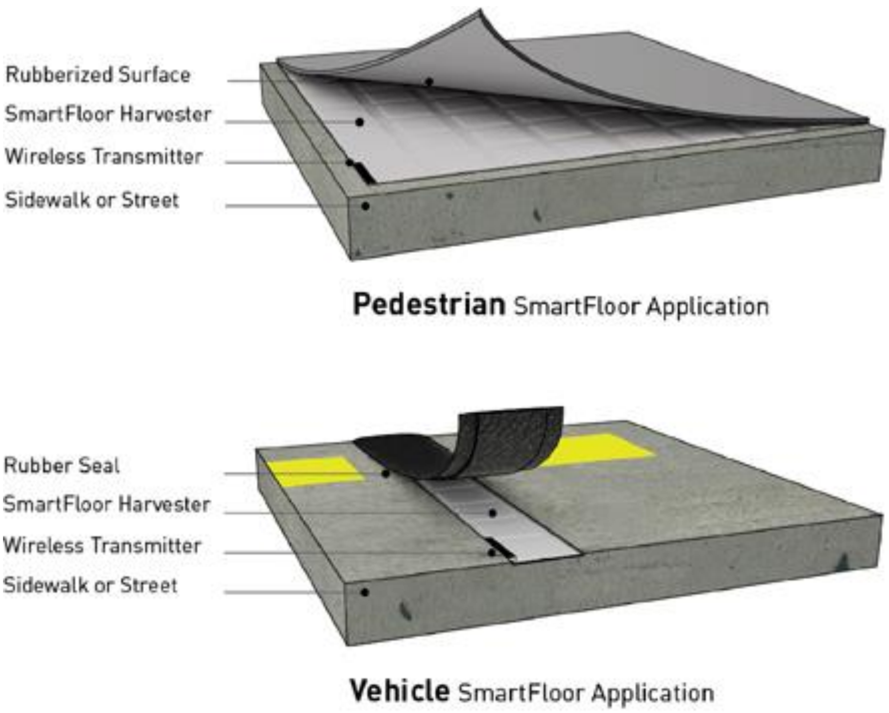

Figure (2) Pavagen piezoelectric company (www.wevolver.com)

3.2 VARIOUS LOGISTICAL ALLOCATIONS THAT USED PIEZOELECTRICITY

(Chuang, et al., 2016) published a paper explain the importance of remote sensors in logistics and various logistical operations that use tracking and other devices that monitor the movement of products and how to connect these devices to piezo energy to reduce the cost resulting from the use of sensors with non-renewable energy and clarify the extent of the savings.

A scientific paper written by (Zhao et al., 2019) and the research paper describes the energy that was harvested from the piezo energy by devices that extract electrical energy from the movement of trucks and are installed in the axles of the truck and with its movement, vibrations are collected through those devices to convert them into electrical energy that can be used instead of fuel in trucks and charging other devices to benefit The study also shows the savings achieved as a result of piezoelectric energy.

Article written by (Jettanasen et al., 2020) aims to obtain the use of piezoelectric tiles in several countries such as Switzerland, Ghana, and London to reduce the use of fuel energy and reduce carbon emissions to create smart cities that operate with sustainable energy and also shows the difference between carbon emissions before and after the use of the piezo energy resulting from human steps and electronic devices vibrations.

3.3 THE ECONOMIC FEASIBILITY OF USING PIEZOELECTRIC TILES

(Taty-Etienne et al., 2018) published a paper explains the economic feasibility of installing piezoelectric crystals and ceramic tiles made of bio-electric in public roads on which cars run, and the extent of energy produced by them in the state of Pretoria, and the study showed that it was possible to provide sufficient energy for lighting 6 of the lighting poles of pressure The high power of 250 watts, which explains the huge savings due to the piezoelectric tiles.

A research obtained from (Elhalwagy et al., 2016) presented about piezoelectric floors, their cost, types, the extent of their use, the amount of electricity generated from the use of floors made of piezoelectric tiles, and the work of a feasibility study for all types of tiles available at the present time, their prices, and an explanation of the areas in which these tiles are used and the amount of energy The result, but also its life span , From that study, the price of the tiles, the cost of their construction, as well as the energy produced from them and their life span, as well as in the first table, the percentage of electricity from the fuel energy that was saved as a result of using these tiles is clear.

Also to show the ratio in decreasing the cost, (Adnan Elhalwagy et al., 2017) explain if piezoelectric tiles applied on floor in building's interior spaces in different areas public area as shown in table (2), and private spaces as shown in table (3) and how much costs saved from applying these tiles and also explained the different companies that produced piezoelectric tiles.

option	Number of tiles	Company	Initial cost- EGP	saving percentage	total saved amount
1	1334	sound power	2668000	92.69%	33,833,333
2	14	pavagen	490000	98.72%	36,033,333
3	10	SEF	150000	99.48%	27,232,143
4	7	Waynergy	28000	99.93%	36,473,333

Table (2) Output results of public area

option	Number of tiles	Company	Initial cost- EGP	saving percentage	Total saved number
1	1600	sound power	3200000	-8667.12%	3,163,500 -
2	16	pavagen	560000	-1434.25%	523,500-
3	12	SEF	180000	-526.22%	144,054-
4	8	Waynergy	32000	12.33%	4,500

Table (3) Output results of private area

From the results of these papers, it's obtained that piezoelectric tiles are more cost-effective in large and public areas in all types of tiles in all company.

In a study on the extent of applying piezoelectric tiles there, the study showed that many families in India suffer due to the inefficiency of electricity. in some areas, there are frequent blackouts while power generation is lower in other countries. The solution to all this is the introduction and implementation of piezoelectric tiles. These tiles can also be used in places like slums where there are a lot of residents and lack of resources. Tiles can produce, store, and use electricity depending on the power comfort people, Although the cost of tiles is high for most of the population there, the study urges investment in India and believes that the return in the long run will be an economic aid because the tiles will provide electricity that will help, and in the long run the cost of electricity will also be negligible. (Deeya Wadhwa, 2021).

A study of two of the busiest stations in Japanese capitals after installing piezoelectric floor tiles in front of ticket gates showed that every time a passenger stepped on the mats, they released a small vibration that could be stored as energy. Multiplied many times over by the 400,000 people who use Tokyo Station on an average day, according to the East Japan Railway, and there is enough power to light electronic signboards. "We are just testing the system at the moment to examine its full potential," said Takuya Ikeba, a spokesperson for JR East, which indicates self-sufficiency in operating most of the signs and lighting in those stations, which in turn means that regular electricity is not consumed and thus reduces electricity consumption costs. (Julian Ryall,2008)

To achieve the second objective the following questions are used for collecting data and then these data are analyzed.

In this study, the primary data is collected using a non-probability sampling method, in which respondents are selected from different departments especially those who have the basic ideas about the popular technologies in the market. Future ideas prevail in the current technological market, especially in the warehouse sector. This was required as many factors were felt necessary to draw a conclusion based on the outputs received by the samples. It depends not only on consumer behavior but also on the market demands that were focused on during the sample analysis or study. To collect data, a questionnaire is prepared based on the variables and the SPSS program is used to analyze the data that will be collected from the selected sample, and the survey will be conducted using Google Sheets to collect qualitative data.

Data analysis

Data analysis is done as per objectives. To achieve the first objective the following questions are used for collecting data and then these data are analyzed.

Question 1: Will you choose to generate electricity through trucks?

Question 2. Are you interested in producing energy yourself?

Question 3: Have you heard of piezo electricity?

Question 4: How did you learn about this technology?

Question 5. Would you like to install new electronic floor tiles in your warehouse?

Question 6. How many times do the trucks go inside the warehouse per day?

Question 7. What is the truck load per day?

Question 8: How much do you prefer to invest in equipment that can generate electricity for the warehouse?

4. RESEARCH FINDING

The findings are the outcome of reviewing the previous studies, and the result of reviewing the literature is the suggested research theoretical framework "The Research Model". This theoretical framework describes the research problem and defines the research variables to show how they might relate to each other.

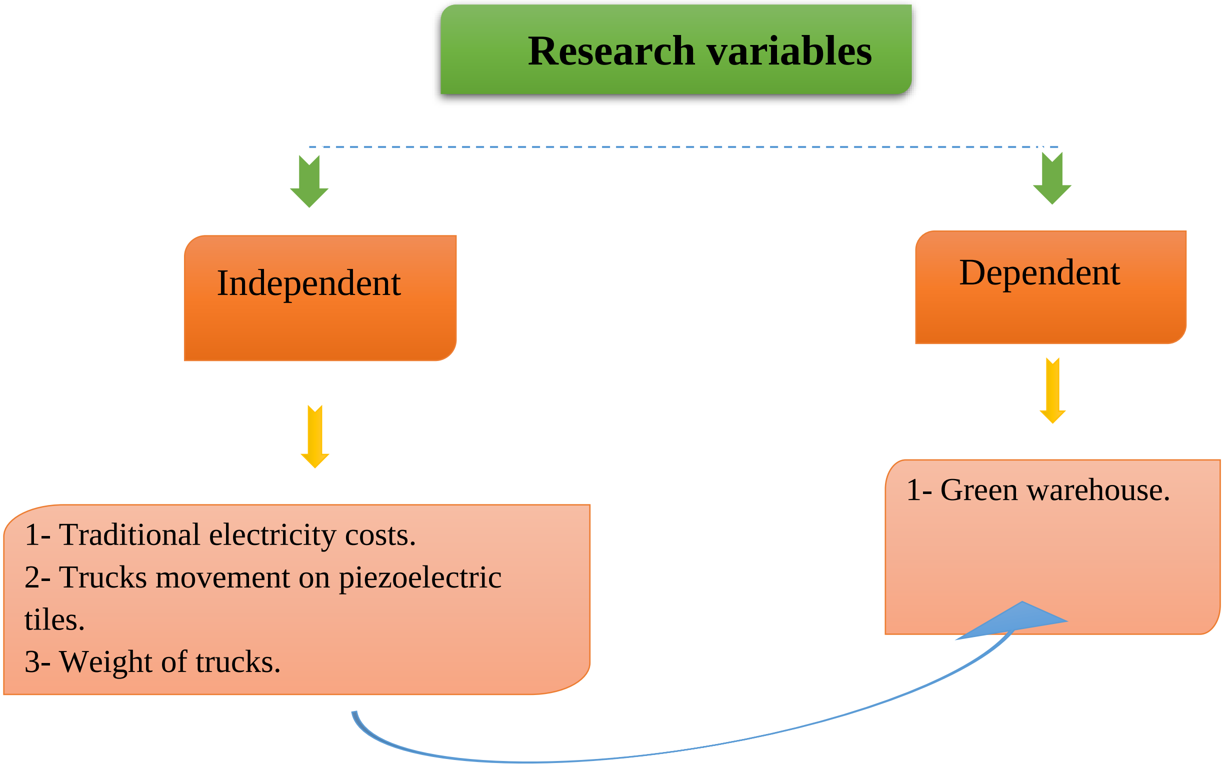

Figure 3: The Research Model

5. CONCLUSION

From the foregoing, it is clear that through previous studies, piezoelectric tiles have done practical and theoretical studies on many scales, whether in the practical field or even daily, and previous studies show the extent of savings, whether providing non-renewable energy or saving related costs, and therefore the presented model can be taken From this research paper, and as for the data that will be collected from the people interested in applying this model and analyzing it, we can obtain the actual percentages of the extent to which piezoelectric tiles can be applied, and obtain the actual results of the extent to which non-renewable energy is provided, as well as the related costs.

6. RECOMMENDATION

The research recommends preparing a case study on one of the major warehouses to compare the situation before and after applying the piezoelectricity technology according to cost levels and obtaining a green warehouse, so we can test the research theoretical framework "The Research Model ".

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PROMOTING AGILE SUPPLY CHAIN MANAGEMENT IN THE EGYPTIAN AGRICULTURAL FOOD SECTOR: ISSUES AND GUIDELINES

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Keywords: Agile Supply Chain, Agricultural Products, Logistics Activities, Competitive Advantage.

1. **ABSTRACT:** Food and agricultural supply chains represent a high percentage of domestic and global trade. To appraise the development of strategies to improve agricultural global supply chain practices and logistics activities, a better understanding of the challenges in supply chains and opportunities for improvement is required. As a result, by investigating current agricultural supply chain issues, this research aims to promote agile supply chain management in the agricultural sector in order to create a competitive advantage for Egyptian agricultural food products. This would contribute to sustainable practices by leading to higher agricultural productivity, profitability, and customer satisfaction. A systematic review of twenty-three published studies on agile agricultural supply chain management was conducted with the purpose of identifying the main issues of the logistics activities in agricultural food shipments, the methods used in the previous studies, the lessons learned from implementing agile supply chain management in the agricultural food sector, and the previous researchers' recommendations for the further studies. followed by semi-structured interviews with the Egyptian logistics providers, food importers, exporters, and maritime port authorities to assess the current issues and challenges that are faced by the Egyptian food importers and exporters and recommend solutions and guidelines to create a competitive advantage for the Egyptian agricultural food products. The findings revealed that logistics activities in Egypt need to be operated more efficiently, especially warehousing and transportation operations. Moreover, it provides information that can assist in developing effective strategies to ameliorate the conditions of agricultural stored products in ports and waterways through a roadmap and to identify research gaps and potentials for future research.

2. INTRODUCTION

In today's competitive world, the supply chain is a crucial element for becoming competitive and successful. Uncertainty in the functioning of any of the links may lead to delays and bottlenecking and may obstruct the performance of the logistics activities. Hence, it is necessary to implement an agile strategy (Patil et al., 2021). Agile Supply Chain (ASC) could be defined as "the strategic ability to respond quickly and on the spot with the help of the effective supply chain relationships established to internal and external uncertainties." In addition, it is the ability of the organisation to use its resources in a timely and flexible manner to respond proactively and reactively to the opportunities and challenges that develop in the internal and external environment of the organisation (Çelikkol et al., 2021).

The agriculture food sector is characterised by the risks associated with its seasonality, sensitivity, increased supplies, long delivery times, specialised transportation and storage processes, and flexibility, which can affect its freshness and health. Therefore, the improvement of its supply system from the producer of agricultural products to consumers is an urgent issue. This could be facilitated by an ASC (Syromyatnikov et al., 2020).

Agri-food business is a vital sector of the Egyptian economy, it contributes 11.4% to the country's GDP and provides 23.3% of employment. The main agricultural products in Egypt include rice, wheat, maize, cotton, sugarcane, and agricultural crops such as vegetables, fruit, and dates (Fouad, 2022). Therefore, agriculture is traditionally a driving force of the Egyptian economy, and the majority of Egyptians rely on agriculture to feed their families and earn a livelihood (FAO, 2015).

In Egypt, the agri-food business comprises three categories: the primary production of both agricultural and agro-processed products; the production of intermediate inputs that are used to produce these primary products, such as fertilizers and seeds; energy; and packaging materials for agro-processed products; and the trade, transport, and marketing of both agricultural and agro-processed goods (Hatab & Hess, 2013). However, food loss and waste (FLW) in Egypt are growing concerns, as the Egyptians throw away between 15 and 45 percent of their food every year, and more during special occasions such as festivals and holidays (FAO, 2019).

Therefore, the aim of this research is to promote agile supply chain management in the agricultural sector in order to create a competitive advantage for Egyptian agricultural food products. This aim will be achieved by three objectives comprising: illustrating the challenges and lessons learned from agile supply chain management in the agri-food sector, investigating the current agricultural food supply chain challenges in Egypt, and proposing some recommendations to achieve agile agricultural supply chain management in Egypt.

Consequently, this paper is structured in five sections: first, the introduction, then, the research questions are addressed and the methodology used; furthermore, a systematic literature review (SLR) is conducted with the aim of highlighting the challenges and learned lessons from implementing agile supply chain management in the agricultural food sector; followed by a semi-structured interview to investigate the challenges and opportunities in Egypt. Finally, the research is concluded and a roadmap is proposed to provide a summary of the issues and guidelines for the supply chain of agri-food sector practitioners.

3. METHODOLOGY

In order to provide a comprehensive study that help the Egyptian agricultural food supply chain practitioners in achieving a competitive advantage and agile supply chain management, the following research questions will be investigated:

RQ1: What are the challenges and lessons learned from agile supply chain management in the agri-food sector?

RQ2: What are the current agricultural food supply chain challenges in Egypt?

RQ3: How to achieve agile agricultural supply chain management in Egypt?

To begin with, to investigate the first question, a systematic literature review was conducted. To report a systematic literature review, there are indispensable nine steps that should be followed. It should start with formulating clear research questions. Followed by writing a systematic literature review procedure. Then using selected keywords to get relevant data from databases. Once the articles with related keywords are collected, date restriction is used to refine the results only based on recent data. Afterward, abstract screening and full text screening. Subsequently, select the relevant sources that only bring about the desired outcome. Later, after analyzing the data and assessing the required data. Finally, a systematic review report was followed by publication (Knoll *et al.* 2018).

Accordingly, based on this systematic procedure, the keyword are selected to be "agile supply chain," *"agricultural food," "logistics activities," and "maritime transport,".* Then, three research engines are used, including Emerald Insights, Research Direct, and SCOPUS to collect related articles such as peer-reviewed journals and conference proceedings and restricted from 2012 to 2022. This inclusion criteria could be shown in the following figure:

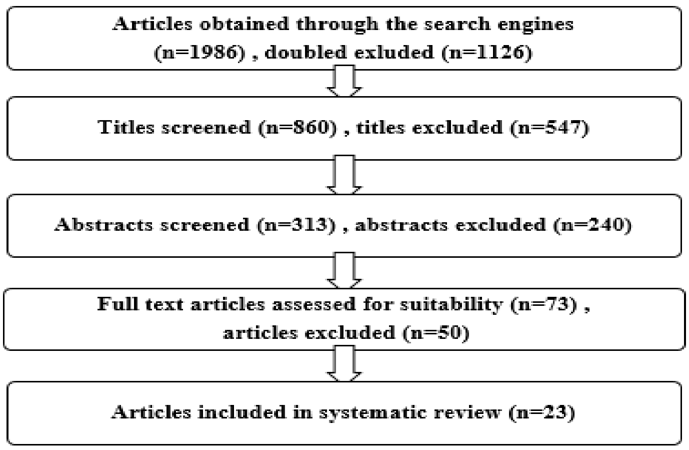

Figure. 1: Flow chart of selection of studies

While for the other two questions, three semi structured interviews were conducted with the Egyptian practitionars including a logistics specialist from logistics provider company, an operational manager from food import and export company, and a representative from cargo handling company in Alexandria port. The interviews are divided into two sections; the first section includes open ended questions that assess the Egyptian Agri-food supply chain challanges, and the second section inlcudes questions that ask the interviewees about their recommendations to acheive agile supply chain management in the Agri-food supply chain sector.

This conducted methodology could be shown in the following figure:

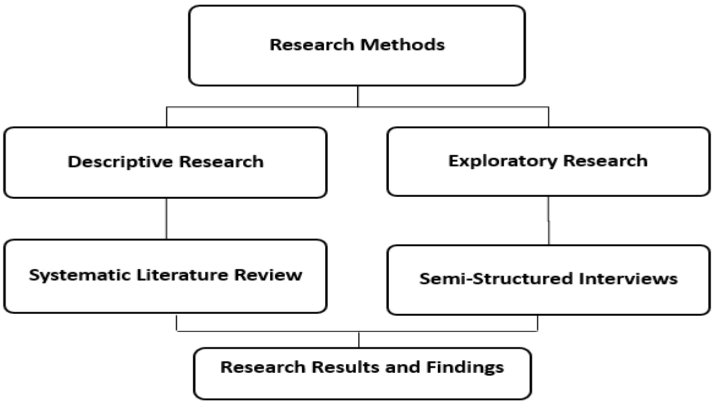

Figure. 2: Research Design

4. DISCUSSION & RESULTS

4.1. The Challenges and Lessons Learned From Agile Supply Chain Management In The Agri-Food Sector

From the conducted systematic literature review, the previous studies have revealed the following recommendations to overcome the challenges faced by agri-food practitioners to achieve an agile supply chain and reduce wastes:

- (Adams et al., 2021), (Aramyan et al., 2021), (Syromyatnikov et al., 2020), (Nketia & Quaye, 2015), & (Driouech et al., 2014) stated that improving communication between all stakeholders through integrated systems could ensure the process- and market-induced standards and quality requirements in order to minimise food wastes and achieve an agile supply chain in the agri-food sector.

- In addition, (Remondino & Zanin 2022), (Yadav et al., 2021), (Abideen et al., 2021), (Syromyatnikov et al., 2020) (Steur et al., 2016) & (Zecca & Rastorgueva 2014) stated that transformation towards agricultural food supply chain 4.0 and value-stream mapping (VSM) creates transformation both in the quality and safety of food products. Moreover, technology has been adopted to improve resource efficiency and productivity in food systems. This has reduced agricultural raw material inputs to reduce environmental externalities. It is also necessary to legislatively regulate the partnership between agribusinesses participating in digital platforms and blockchain technologies.

- Furthermore, (Álvarez et al., 2021), (Raut, & Gardas, 2018), (Kresnanto et al., 2021), (Driouech et al., 2014) revealed that effective multi-modal transportation may be used to significantly save transportation time for perishable food products. Also, the selected transportation mode should be environmentally friendly. Moreover, the loading and unloading activities should be carried out under supervision to reduce the wastage of the produce. In addition, to reduce the handling of the individual packages and save time on handling machinery such as forklift trucks, last but not least, the drivers of the vehicles play a significant role in reducing the transportation losses, hence, responsible and experienced drivers should be employed.

- Besides, (Carter et al., 2022), (Rahimi, & Artukoglu, 2021), (Islam et al., 2021), (Kharaishvili et al., 2021), (Szerb et al.,2018), (Nketia & Quaye, 2015), (Driouech et al., 2014), (Rueda et al., 2021), (Álvarez et al., 2021), & (Barana & ĩak 2014) revealed that constructing more efficient infrastructure and links between countries and cities could reduce the food wastes as the distance between them will be shorter in time. In addition to constructing new logistics areas supported with refrigerators and reefer containers for storing, and transporting Agri-food products. Also, dry ports are essential for providing logistics services for food to minimise waste, avoid the waiting time in ports, and increase the added value of domestic export items.

- Finally, (Nunes et al., 2014), (Li et al., 2015), & (Albaar et al., 2016) stated that in order to achieve a sustainable and competitive food supply chain, using green transportation and packaging is essential, especially for maritime transportation and short sea shipping modes. And minimise the dependency on road transportation. Also, it is crucial to have sufficient insights into product temperature during transportation.

Therefore, the following table summarizes and identifies the main challenges and opportunities of the supply chain and logistics activities in agricultural food sector:

Table 1. A systematic literature review

No	***Year of Publication***	***Title***	***Focus***	***Findings***
1	2012	Determining Factors in Port Competitiveness: The Case of Fresh Fruit and Vegetable Produce Traffic in Spanish Ports	Analyze the factors of competitiveness of ports with regard to agri-food products. 27 Spanish port authorities was used as a data panel.	• For Any port to become competitive with regard to agri-food products, the existence of a logistics area inside the ports for transporters, the availability of high capacity and dry-port facilities are essential.
2	2014	Supply Chain Management and Sustainability in Agri-Food System: Italian Evidence	Examine the main challenges for the supply chain sustainability in the Italian agri-food value chain. A case study on Italy is used by collecting data from different sources.	• Italy is lacking knowledge sharing, logistics technologies, and collaborated and integrated views.
3	2014	Improvement in fresh fruit and vegetable logistics quality: berry logistics field studies	Explore a blueberry supply chain and illustrate how using accelerated shelf-life loss data to manage inventory rotation by first expiring first out (FEFO) versus first in first out (FIFO).	• FIFO inventory strategy is not capable of eliminating waste caused by accumulated, invisible, shelf-life loss. Hence, RFID temperature monitoring technology is important to significantly

			A field study is used on blackberries in Mexico.	reduce waste and increase quality, profit, jobs in producing countries.
4	2014	Multiple Criteria Evaluation of transportation performance for selected agribusiness companies	Evaluate transportation performance of transportation in agribusiness companies. A Multiple Criteria Analysis (MCA) is used.	• Bad transport quality. • Lack of safety precautions. • Lack of fleet utilization.
5	2014	Agri-Food Logistics In The Mediterranean Region: Challenges And Opportunities	Assess the performance of logistics, and the challenges facing the agri-food trade to develop the logistics sector, especially transport and cold chain, in the Mediterranean region. Secondary data collection is used.	• Mediterranean ports are not able to meet the specific requirements for the transport and distribution of fresh fruit and vegetables. • Road transport is still by far more expensive than sea transport and only possible for intra community goods transport. • Road transport is faced with external constraints such as traffic jams, pollution, and highway maintenance.
6	2015	Appraisal of Logistics Management Issues in the Agro-Food Industry Sector in Ghana	Investigate the existing logistics management practices in 20 selected agro-food enterprises in Ghana. In-depth case studies is used.	• Inadequate cold storage facilities. • Lack of training in logistics management among others. • Inadequate cold vans. • Poor road networks.
7	2015	Cutting Food Waste through Cooperation along the Food Supply Chain	Investigate the causes and effects of food wastes and to find methods to reduce it. 44 qualitative expert interviews were conducted in Germany.	• Food waste occurs at all stages in the food chain especially in the agricultural process and transportation process which results in rejecting the quality of the food. Hence, it is important to improve it.
8	2015	Assessingthe transfer of risk due to transportation of agricultural products	Assess the significance of the transportation of agricultural products in Health risk assessment (HRA). A case study on Taiwan is used.	• Transportation of agricultural products is the major factor causing the transfer of risk between different countries as the agri- products will be more exposed to pollution.
9	2016	Applying Value Stream Mapping to reduce food losses and wastes in supply chains: A systematic review	Investigate the impact of applying Value Stream Mapping (VSM) on reducing Food Losses & Wastes (FLW) in the supply chain. A systematic review of 24 articles was conducted.	• VSM has shown to improve the visibility of supply chain and creates information sharing method that is necessary to reduce FLW. • It improve production efficiency through the reduction of production costs, and hence the prices of food. • It eliminates unnecessary inventory and excess stock by eliminating uncertainty

				in supply chain.
10	2016	Influence of secondary packaging on quality of carrots during transportation	Illustrate the influence of packaging on quality change of carrots during transportation. A case study on farmers in Ciherang is used.	• The kind of packaging especially using plastics and longtime of transportation will negatively influence the level of damage.
11	2018	Logistic Challenges In The Short Food Supply Chains	Identify the logistical problems and solutions in the short food supply chains (SFSCs). A review was conducted on the Hungarian food supply chain.	• Refrigerated storage should be handled with operators who have the required knowledge to minimize logistics costs and limit emissions. • Transport vehicles should be loaded to its full capacity.
12	2018	Sustainable logistics barriers of fruits and vegetables - an interpretive structural modeling approach	Identify the causal factors of post-harvesting losses occurring in the transportation phase. Literature survey and expert opinions are used and analyzed by Interpretive structural modelling (ISM).	• Improper packaging, • Improper handling of packages, • Non-availability of refrigerated vehicles, • Packages getting exposed to the sun and rain while loading and loading, • Vibration of the vehicle, • Bad condition of roads, • Rash driving, • Excessive loading on the vehicles.
13	2020	Agile Supply Chain Management in Agricultural Business	Study agile supply chain management methods in agricultural business in small and medium-sized enterprises in Russia. A survey is conducted with the supply chain participants including manufacturers, wholesalers and consumers.	• Lack of digital platforms in the agricultural business market, • Weak partnership of manufacturers, • Poor awareness to use flexible supply chain management methods • Insufficient legislative regulation in the field of agricultural production and supply chain management • Lack of staff training sessions.
14	2021	A systematic literature review of the agro-food supply chain: Challenges, network design, and performance measurement perspectives	Identify the challenges in the Agriculture Food Supply Chain (AFSC). A systematic review of 108 articles are reviewed.	• Food waste, food safety and security, and miscellaneous are the main challenges including • Transportation, poor packing, strict export standards, improper cooling, poor storage facilities and inventory management. And for the common key indicators to measure the performance of AFSC are efficiency, flexibility, food quality and responsiveness.
15	2021	Achieving sustainability in food manufacturing operations and their	Identify how food manufacturing companies implement sustainability in their supply chains and the barriers to waste	• Insufficient transport quality • packing failure • Distribution among all the entities and • Lack of reverse logistics activities.

		supply chains: Key insights from a systematic literature review	and recycling management. A systematic review of 130 articles were reviewed.	Hence, shipments delays might occur which will result in causing negative impacts on the environmental sustainability
16	2021	Food waste reduction in supply chains through innovations: a review	Analyze the drivers and the barriers that affect the decision of supply chain operators to adopt innovations to reduce food wastes. A narrative literature review was carried out.	• Types of innovations have a high potential in reducing and preventing food wastes along the supply chain; however, they still must be economically feasible to be adopted by decision makers in the food supply chain.
17	2021	Efficient agri food supply chain in a sustainable transportation perspective	Discuss transportation sustainability in support of a sustainable supply chain from warehouses to end users, especially in agri-food products. A comprehensive review of several previous studies is used.	• The use of multimodal is the most rational consideration to meet green transport and sustainable food agriculture objectives in terms of travel costs and environment.
18	2021	Food Supply Chain Transformation through Technology and Future Research Directions—A Systematic Review	Review the digital and smart supply chains in eliminating waste in the food chain. A systematic review is used by reviewing articles from 2010 to 2021.	• Achieving transformation in the food supply chain would need a significant shift in operator's attitudes, as well as the roles and duties of public sector actors to apply smart packaging and warehousing using RFIDs and transportation using IoT.
19	2021	Finding Competitors And Strategies In Maritime Transportation Of Fruits And Vegetables In Spain	Propose model to the maritime traffic flow of some food products, traded internationally from Spain to reduce wastes. Complex network analysis (CNA) is used.	• There is a potential for the development of intermodal transport in general and maritime transport in particular in the area, which could certainly be helped by the effective development for the implementation of corridors.
20	2021	Problems Facing Agricultural Product Exporters and Solutions : A Case Study from Afghanistan	Investigate problems faced by agricultural product exporters in Afghanistan and propose solutions. A questionnaire is used with practitioners in Afghanistan.	• Inadequacy of government support • taxes and customs clearance • Transit transportation problems • Lack of quality control systems.
21	2021	Conceptual Study of Problems And Challenges Associated With The Food Supply Chain in Developing Countries	Review the main problems associated with the food supply chain in developing countries. A narrative review was conducted	• Absence of infrastructure for cold chains • Lack of modern processing facilities that result in high inadequacies and losses of food.
22	2022	Supply chain disruptions and	Investigate the trade effects of the 2021 supply chain disruptions on	• Port congestion and container shortages for containerized agricultural

		containerized agricultural exports from California ports	containerized agricultural exports from California ports. A case study and Panel Data Collections are used.	exports are the main challenges due to the world economic recessions.
23	2022	Logistics and Agri-Food: Digitization to Increase Competitive Advantage and Sustainability. Literature Review and the Case of Italy	Examine the current challenges faced by logistics with a focus on the agri-food sector in Italy. A review is conducted by presenting Italy as a case study.	• Digitization and new technologies are essential to support logistics and sustainability such as IoT, Bloch chain, and bridging an Infrastructure gap with digitization.

4.2 Assessing the current situation of the Egyptian agri-food sector

In order to identify the challenges and issues that are faced by the egyptian agri-food sector practitioners and recomend solutions and guidelines to create a competitive advantage for the egyptian agricultural food products, three semi-structured interviews were conducted. The interviews revealed that in order to achieve agile supply chain management, there are a lot of challenges in Egypt should be managed including: unavailability of equipped transportation means (reefer trucks), inadequate storage facilities for perishable agricultural products, lack of skills of new innovative farming methods, lack of integrated systems that alerts for wastes and losses, inadequate trucks and containers for carrying agri-food products that causes pollution, competition between different exporters, mainly in terms of prices, product quality and standards, and promotional efforts, raising sea level, land drought, spillage, damage or contamination causing quality and quantity loss due to inadequate processing and packaging methods, damage and spillage during transport because of inadequate transportation and distribution systems, spilled or damaged crops and products in market due to inadequate infrastructure and poor handling, and deterioration in quality and pests/disease attacks due to inadequate storage facilities and techniques.

4.3 Recommendations To Achieve Agile Agricultural Supply Chain Management In Egypt

.The following roadmap represent the interviews outcomes of the current issues with their aggregated guidelines to achieve agile supply chain management in the agri-food sector.

TABLE 2. Roadmap for The Current Issues And Opportunities In The Egyptian Agri-Food Business

Agri-Food Supply Chain Issues	*Guidelines*
Lack of logistics activities management	• Conducting awareness campaigns. • Encourage private and public partnerships to increase logistics efficiency with foreign logistics investors • Enhance the educational level in Egypt concerning the logistics concept.
Climate change and Land Use Issues	• Assess the impacts of climate change on the domestic industries and environment and build a policy framework to minimize its impacts.
Competition	• Explore the global opportunities for Egyptian products

in International Markets	
Lack of digitized systems and Green Transportation	• Supporting market information flows, access to knowledge and training, and vertical linkages among small-scale farmers, traders, transporters, and buyers • Developing a monitoring system for losses.
Physical Infrastructure	• Develop a plan for multimodal infrastructure development. • Establish a successful partnership with foreign countries to implement their road and maritime infrastructure strategies in Egypt.
lack of qualified labor force	• Training in post-harvest handling for value chain actors focusing on packaging, marketing, distribution, research & development (R&D).

5. CONCLUSIONS AND FURTHER RESEARCH

In conclusion, this research contributed to knowledge by providing an overview on the main issues of the supply chain and logistics activities in agricultural food shipments with the aim of promoting agile supply chain management in the agricultural sector in order to create a competitive advantage for Egyptian agricultural food products. The findings revealed that logistics activities in Egypt need to be operated more efficiently as mentioned in the previous roadmap which discusses the problems including the inadequate infrastructure, limited transport capacities and resources, a lack of skilled labor force, the need to comply with carbon emission standards, and increasing operational costs due to warehousing issues. The major problems in Egypt which results in the over costs are the warehousing and transportation operations as they are considered from the highest logistics cost. Hence, a further research could be proposed to find and apply more solutions as follows:

- To conduct a research that investigates the impact of investing in agri-food integrated supply chain systems on the efficiency of the agri-Food supply chain.
- To conduct a research that investigates the applicability of applying multimodal networks and new logistics areas for transporting and storing agri-food products in Egypt.
- To conduct a research that investigates the development of the Egyptian seaports to be able to handle agri-food products in an efficient manner.

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Green Transition and Renewable Energy

A cost-benefit analysis of the use of ammonia and hydrogen as marine fuels

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Keywords: shipping; decarbonization; alternative fuels; hydrogen; ammonia.

1. **ABSTRACT:** A major challenge for the maritime industry during the last decades lies with its "obligation" to reduce the greenhouse gas (GHG) emissions from its operations and contribute to both global and regional targets for climate neutrality and decarbonization, like the Paris Agreement and the European Green Deal. In this direction, the "IMO Initial Strategy for the Reduction of GHG emissions from Shipping" calls for urgent action in order to reduce shipping GHG emissions by 50% by 2050 -when compared to 2008- and completely decarbonize the industry before the end of this century. The replacement of fossil fuels by alternative fuels and energy sources is absolutely necessary in this respect and a number of alternative fuels with GHG emission reduction potential have been proposed and considered for marine application. Among the different marine fuels, hydrogen and ammonia seem to have the higher environmental benefits and potential to achieve the decarbonization of maritime transport, but their adoption comes with high capital investments for the installation of new engines and fuel systems, port infrastructure, and increased operational costs due to their high prices compared with the conventional fuels. This paper analyses the costs and benefits associated with the use of hydrogen and ammonia as marine fuels focusing on various production methods, comprising blue fuels – produced from fossil sources and using carbon and capture storage (CCS) - and green fuels – coming from renewable energy sources. A cost-benefit analysis of the use of hydrogen and ammonia as marine fuels is essential in order to specify and underline the cost differences between these fuels and the conventional ones and make policy recommendations on how this existing 'cost gap' could be somehow alleviated through market-based measures (MBMs) to stimulate further investments on

these fuels. Additional identified challenges associated with the use of these fuels – including availability, safety and regulatory aspects - are also touched upon in this paper.

2. INTRODUCTION

A major challenge for the maritime industry during the last decades lies with its "obligation" to reduce the greenhouse gas (GHG) emissions from its operations and contribute to both global and regional targets for climate neutrality and decarbonization, like the Paris Agreement and the European Green Deal. In this direction, the "IMO Initial Strategy for the Reduction of GHG emissions from Shipping" calls for urgent action in order to reduce shipping GHG emissions by 50% by 2050 -when compared to 2008- and completely decarbonize the industry by the end of this century (MEPC, 2018). The Initial IMO GHG Strategy incorporates a large variety of technical and operational measures for the improvement of the sector's energy efficiency. At the same time, it "suggests" the introduction of market-based measures (MBMs) in order to provide additional incentives for investments on green technologies and underlines the urgent need for the replacement of fossil fuels by alternative fuels and energy sources for the achievement of shipping decarbonization.

Besides the global regulations and initiatives for the decarbonization of the maritime industry, the European Green Deal and the most recent European Union's (EU) "Fit for 55" package include specific legislations that target the drastic reduction of GHG emissions from shipping at European level recognizing the crucial contribution of shipping in the overall efforts for the achievement of climate neutrality in Europe by 2050 and the reduction of the relevant emissions by 55% by 2030 (Council of the European Union, 2021). A number of legislation tools within the EU's "Fit for 55" package seek to improve the energy efficiency and carbon footprint of shipping with the most 'mature' being the inclusion of shipping in the EU Emissions Trading System (EU ETS) that is planned to enter into force in 2024. Another important regulation that aims to significantly increase the employment of alternative marine fuels and energy sources is the FuelEU Maritime Initiative that "sets specific GHG intensity limits on the energy used on-board ships" and is planned to enter into force in 2025. More specifically, the FuelEU Initiative requires all vessels operating within the EEA, departing or arriving from/to an EU port to meet specific GHG intensity limits that will gradually become stricter – starting from 2025 to 2050 – with the GHG reductions required in 2050 reaching 75% of the energy used in 2020 that is baseline year for the implementation of the Initiative (Christodoulou and Cullinane, 2022).

In this respect, a number of alternative fuels with GHG emission reduction potential have been proposed and considered for marine application (Bouman et al., 2017; Wan et al., 2018; Foretich et al., 2021). Among the different marine fuels, hydrogen and ammonia seem to have the higher environmental benefits and potential to achieve the decarbonization of maritime transport, but their adoption comes with high capital investments for the installation of new engines and fuel systems, port infrastructure, and increased operational costs due to their high prices compared with the conventional fuels (McKinlay et al., 2021; Wang et al., 2021; Masodzadeh et al., 2022). Additional barriers for the wide adoption of hydrogen and ammonia as marine fuels are the safety considerations associated with their use, the existing regulatory framework that does not include them as "certified" marine fuels and their current limited availability that cannot meet the energy needs of the global fleet (Ampah et al., 2021).

This paper analyses the costs and benefits associated with the use of hydrogen and ammonia as marine fuels focusing on various production methods, comprising blue fuels – produced from fossil sources and using carbon and capture storage (CCS) - and green fuels – coming from renewable energy sources. A cost-benefit analysis of the use of hydrogen and ammonia as marine fuels is essential in order to specify and underline the cost differences between these fuels and the conventional ones and make policy recommendations on how this existing "cost gap" could somehow be alleviated through market-based measures (MBMs) to stimulate further investments in these fuels. Additional identified challenges associated with the use of these fuels – including availability, safety and regulatory aspects - are also touched upon in this paper.

The paper is organized as follows: A short introduction on blue/green hydrogen and ammonia as marine fuels is provided in Section 3 followed by Section 4 that presents the method and data used in this analysis. The results from the cost-benefit analysis of the use of these alternative marine fuels are analysed and discussed in Section 5. Section 6 presents the main conclusions and policy recommendations of this research.

3. GREEN AND BLUE HYDROGEN AND AMMONIA

Both hydrogen and ammonia can be employed as marine fuels in different forms based on the energy sources used for their production. In case their production is based on fossil energy sources, they can be grey or blue hydrogen or ammonia; in case they are produced from renewable energy, they are called green or e-fuels. Blue hydrogen and ammonia – in contrast to grey fuels – use carbon capture and storage (CCS) technology during the fuel production in order to reduce their carbon intensity, a reduction that reaches up to 90% compared to grey fuels. Besides their low carbon intensity from the use of CCS, blue hydrogen and ammonia cannot be considered as fossil-free fuels in contrast to green hydrogen and ammonia that are produced from electricity coming from renewable energy sources such as solar, wind, hydro, tidal wave, and geothermal energy. At the moment, the vast majority of hydrogen produced (95%) comes from fossil fuels, while only 5% being green hydrogen produced through electrolysis.

The carbon intensity of grey hydrogen is higher than heavy fuel oil (HFO) and marine gas oil (MGO); GHG emissions reductions from the use of green hydrogen are, though, even higher than 85% of conventional fuels. Green hydrogen is a sulfur free fuel with very low carbon intensity that could be used for the energy transition of maritime transport. There are, though, some characteristics of the fuel that make it less attractive compared to other options. A practical disadvantage of using hydrogen as marine fuel comes from its low energy density that requires high fuel storage volumes onboard and reduces the cargo space on the concerned vessels. Its volumetric energy density is low (5.14 GJ/m^3) when stored in compressed state at 80 MPa pressure, and slightly higher (8.55 GJ/m^3) when stored as liquid at cryogenic conditions (-253°C) (Lemmon et al., 2010). It is exactly this low volumetric energy density of hydrogen that makes weak its business case for use in deep-sea shipping where the needed fuel storage volumes are very higher compared to conventional fuels. Additionally, hydrogen is easily ignitable over a wide range of fuel-air mixing ratios and has a Global Warming Potential over 100 years estimated to be between as high as 11 (Sand et al., 2020). These conditions turn safe storage and handling of hydrogen onboard the vessels into major challenges for the employment of hydrogen as marine fuel with the need to pay particular attention to safety considerations.

The demand for hydrogen as marine fuel is still emerging at the moment, with no distribution or bunkering infrastructure for ships currently in place. There are, though, upcoming port initiatives on the building of refueling points for hydrogen at major ports around the globe, with the Port of

Rotterdam standing out. The unique areas where ports are located also turn them into promising energy hubs for the production and storage of renewable energy that could also be used for the production of green fuels.

Coming to the employment of ammonia as marine fuel, the GHG footprint of this fuel depends on the energy sources used for its production. As in the case of hydrogen, grey ammonia usually comes from natural gas or coal and has a carbon footprint close to fossil fuels; green ammonia, though, that comes from renewable electricity, water and air can lead to almost zero CO_2 emissions while blue ammonia that comes from fossil sources, but uses CCS during its production can also drastically reduce CO2 emissions (Hansson et al., 2020). However, the high toxicity of ammonia and safety considerations that come with its handling as a marine fuel need to be addressed (Prussi et al., 2021).

Compared to hydrogen, ammonia is easier and less energy consuming to store requiring less severe temperature and pressure conditions for its transportation. More specifically, the conditions at which ammonia becomes liquid are either (-33°C) at atmospheric pressure, or 15 bar at atmospheric temperature (25°C) (Lemmon et al., 2010), which are well below the ones required for hydrogen storage onboard. Moreover, ammonia is already transferred as a cargo by sea with 120 ports across the globe already having in place facilities for handling ammonia. Yet, the toxicity and volatility of ammonia remains an important albeit manageable challenge (Schönborn & Lee, 2022). The bunkering infrastructure for ammonia is not yet in place in any port around the world; this consists one of the main challenges for its wider adoption as a marine fuel along with the limited availability of ammonia, and especially green ammonia. It is also necessary to factor in that the production of green ammonia is currently emerging (77% of ammonia produced globally is grey, the high investment costs associated the land-based infrastructure are an additional challenge for its wider adoption as a marine fuel (Krantz et al., 2020)).

4. METHOD/DATA

After this short introduction to green/blue ammonia as marine fuels and their potential to fully decarbonize the maritime sector, this paper analyses the costs and benefits associated with the use of these fuels. A cost-benefit analysis of the use of hydrogen and ammonia as marine fuels is essential in order to specify and underline the cost differences between these fuels and the conventional ones and make policy recommendations on how this existing 'cost gap' could be somehow alleviated through market-based measures (MBMs) to stimulate further investments on these fuels.

In order to estimate the costs associated with the employment of hydrogen and ammonia as marine fuels, the cumulative cost for the lifespan of a ship is calculated using the function below considering both the capital expenditure (CAPEX) and the operational expenditure (OPEX) (Kim et al., 2020). The CAPEX includes the investment cost in €/kW for the propulsion systems, including engines and components (for four-stroke and two-stroke engines) (Korberg et al., 2021), while the fuel costs are included in the OPEX.

(1) $$\text{Cumulative cost} = CAPEX + \sum_{n=1}^{n=25} \frac{OPEX*(1+i)^n}{(1+d)^n}$$

where n is the age of the ship from 1 to 25 years, d is the discount rate and r is the inflation rate.

Based on Korberg et al. (2021), the investment cost in €/kW for the different propulsion systems, including engines and components (for four-stroke and two-stroke engines) can be found in Table 1 along with the cost of the SCR (45€/kW). The fuel prices for MDO, NH3 and H2 are also shown in Table 2 and are based on Inal et al. (2022).

Table 1. Investment cost in €/kW for the different propulsion systems, including engines and components (for four-stroke and two-stroke engines)

Engine type	*Fuel*	*Engine cost/kW*
4-stroke (4S)	*MDO*	*240*
	NH3	*370*
	H2	*470*
2-stroke (2S)	*MDO*	*460*
	NH3	*600*

Table 2. Fuel prices in €/tonne of fuel for MDO, NH3 and H2 (Inal et al., 2022)

Fuel	*Fuel price*	*2036-2050*
MDO	*550*	
Blue NH3	*375*	
Green NH3	*750*	*360*
Blue H2	*2200*	
Green H2	*5500*	*2600*

It needs to be mentioned here that the fuel prices for green hydrogen and ammonia for the period 2036-2050 are based on the authors' assumptions that the increased demand for these fuels and the technology maturity for their production will lead to reduced prices over the years.

In order to estimate the benefits from the employment of blue/green hydrogen and ammonia as marine fuels, the emission costs from the use of the different marine fuels were calculated by multiplying the life-cycle emissions from the use of each fuel with the fuel consumption of the vessel and the emission costs per tonne of emission using the formula below:

$$C_{m,m',bn,gn,bn',gn',bh,gh} = E_{c,s,n,p} * C'_{c,s,n,p} \quad (2)$$

where Cm,m´,bn,gn,bn´,gn´,bh,gh are the emission costs from the use of the MDO in 4stroke engines, MDO in 2stroke engines, blue and green NH3 in 4stroke engines, blue and green NH3 in 2stroke engines and blue and green H2 in 4stroke engines. Ec,s,n,p are the life-cycle CO2 eq., SOx, NOx, PM emissions per kWh from the use of the different fuels. C´c,s,n,p are the emission costs per tonne of CO2 eq., SOx, NOx, PM emissions (Victoria Transport Policy Institute, 2020). The emission costs per tonne of pollutant that were assumed in this study are: 90€/tonne of CO2eq., 6500€/tonne of SOx, 4700€/tonne of NOx and 2500€/tonne of PM2,5.

Following the analysis of the emission costs associated with the employment of each fuel, their environmental performance was revealed along with the benefits from their employment. Besides the cost-benefit analysis, we further attempted to incorporate the identified external cost (emission cost) to the production cost in order to underline the actual social cost of each fuel.

5. RESULTS AND DISCUSSION

The first part of this section presents our findings on the costs associated with the use of hydrogen and ammonia as marine fuels, while the second part focuses on the benefits from their employment.

5.1 CAPEX and OPEX for the use of MDO, NH3 and H2 as marine fuels in 4stroke and 2stroke engines

In this study, we analysed the case of a tanker vessel with an engine of 6000 kW, a discount rate of 2% and an inflation rate of 10%. The CAPEX for this vessel for the use of the various fuels will be calculated using the following formula:

(3) *CAPEX = (engine cost/kW + SCR cost/kW) * KW*

The OPEX will be calculated by multiplying the fuel prices with the fuel consumption of each fuel that depends directly on the energy density of the different fuels. Based on the existing literature, the energy density of MDO is 42.6 MJ/kg, of NH3 18.6 MJ/kg and of H2 MJ/kg 120.0 (Dong et al., 2023). It needs to be mentioned here that different scenarios have been considered for the use of each fuel. For MDO, the use of the fuel is 100% at both 4stroke and 2stroke engines, for NH3 the use of 88% of this fuel (and 12% of MDO) is considered for 4stroke engines with these percentages being 95% of NH3 (main fuel injection) and 5% of MDO (pilot fuel injection) for 2stroke engines, for H2 the use of 98.5% (main fuel injection) of this fuel is considered with 1.5% (pilot fuel injection) of MDO for 4stroke engines (Dong et al., 2023).

Following the formula used for the calculation of the CAPEX and OPEX, the yearly CAPEX and OPEX of the tanker for the use of the different fuels can be seen in the following figure 1.

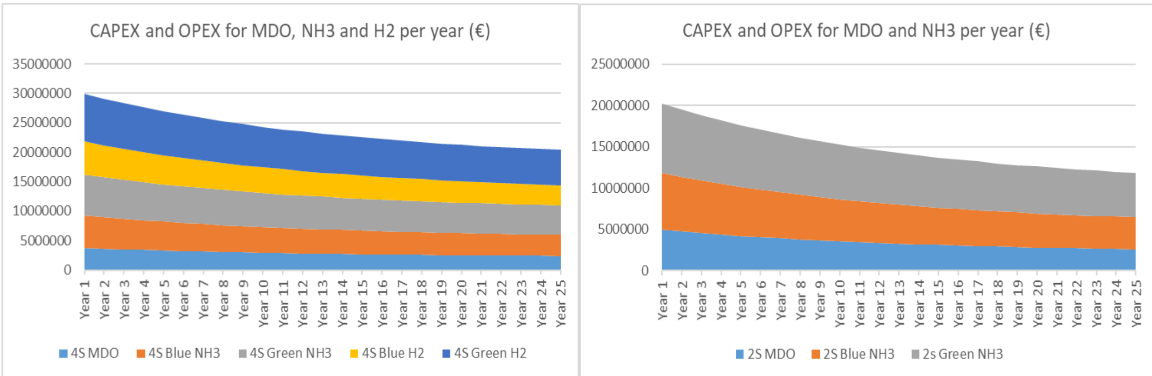

Figure 1: CAPEX and OPEX for different fuels per year (€)

As can be seen in Figure 1, green hydrogen and ammonia are by far the most expensive fuels with their annual cost decreasing over the years, but still remaining much higher than the cost of MDO and blue hydrogen and ammonia. The main reason lies to the high OPEX of green fuels as their price is very high at the moment due to their limited availability and technological maturity for their production. In contrast to conventional fossil fuels, the employment of hydrogen and ammonia imply additional CAPEX coming from the conversion of existing marine engines (Hansson et al., 2020; Lindstad et al., 2021).

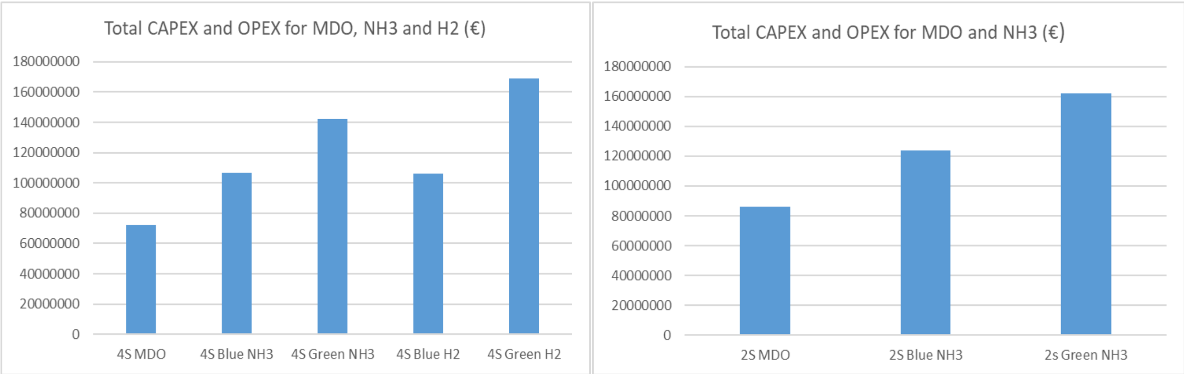

Figure 2: CAPEX and OPEX for different fuels for the whole lifespan of the vessel (€)

Figure 2 presents the CAPEX and OPEX for different fuels for the whole lifespan of the vessel and makes apparent the "cost gap" between the conventional MDO and blue/green hydrogen and ammonia. The overall cost of using green hydrogen (4S engines) reaches almost 170 million euros for the whole lifespan of the vessel, while blue hydrogen costs around 106 million euros compared to MDO that costs around 72 million euros. When green ammonia is used in 4S engines, the fuel costs are double the costs of MDO (142 million euros) and go down to 107 million euros when blue ammonia is used.

5.2 Emission costs from the use of different marine fuels

Shifting the discussion towards the emission costs from the use of the different marine fuels, these were calculated by multiplying the life-cycle emissions from the use of each fuel with the fuel consumption of the vessel and the emission costs per tonne of emission using the formula below:

$$Cm,m\acute{},bn,gn,bn\acute{},gn\acute{},bh,gh = Ec,s,n,p * C\acute{}c,s,n,p \qquad (7)$$

where Cm,m´,bn,gn,bn´,gn´,bh,gh are the emission costs from the use of the MDO in 4stroke engines, MDO in 2stroke engines, blue and green NH4 in 4stroke engines, blue and green NH3 in 2stroke engines and blue and green H2 in 4stroke engines. It needs to be mentioned here that different scenarios have been considered for the use of each fuel. For MDO, the use of the fuel is 100% at both 4stroke and 2stroke engines, for NH3 the use of 88% of this fuel (and 12% of MDO) is considered for 4stroke engines with this percentages being 95% of NH3 and 5% of MDO for 2stroke engines, for H2 the use of 98.5% of this fuel is considered with 1.5% of MDO for 4stroke engines. Ec,s,n,p are the life-cycle CO2 eq., SOx, NOx, PM emissions per kWh from the use of the different fuels. C´c,s,n,p are the emission costs per tonne of CO2 eq., SOx, NOx, PM emissions (Victoria Transport Policy Institute, 2020).

The life-cycle emissions of different fuels include Well-to-Wake GHG emissions of alternative fuels considering both Well-to-Tank emissions generated during the production, process, transport of fuel to the ship and bunkering and Tank-to-Wake emissions produced from the combustion of marine fuels. Based on existing literature, the Well-to-Wake GHG emissions of green ammonia and hydrogen are very low compared to conventional fuels and they have the potential to decarbonize shipping, but – as seen in the previous section – their employment presupposes high operational and capital expenditure and investments in new infrastructure (Hansson et al., 2020; Lindstad et al., 2021). Dong et al. (2023) calculated the life-cycle CO2 eq., SOx, NOx, PM emissions per kWh of MDO, ammonia and hydrogen considering the same scenarios used in this cost-benefit analysis (Table 3).

Table 3. Life-cycle CO2 equiv., SOx, NOx, PM emissions per kWh from the use of the different fuels (Dong et al., 2023)

Scenarios	CO2 equiv.	SOX	NOX	PM
100%MDO+SCR 2-stroke	*6.64E-01*	*2.47E-04*	*1.24E-03*	*3.30E-04*
95%GreenNH3+5%MDO+ SCR 2-stroke	*1.14E-01*	*1.23E-05*	*1.02E-03*	*3.22E-05*
95%BlueNH3+5%MDO+ SCR 2-stroke	*4.18E-01*	*1.23E-05*	*1.45E-03*	*3.71E-05*
100%MDO+SCR 4-stroke	*8.08E-01*	*3.01E-04*	*1.51E-03*	*4.02E-04*
98.5%GreenH2+1.5%MDO 4stroke	5.03E-02	4.67E-06	2.11E-03	1.47E-05
98.5%BlueH2+1.5%MDO 4stroke	3.97E-01	4.67E-06	2.60E-03	2.02E-05
88%GreenNH3+12%MDO +SCR 4-stroke	*3.10E-01*	*8.88E-05*	*1.49E-03*	*1.08E-04*
88%BlueNH3+12%MDO +SCR 4-stroke	*6.45E-01*	*1.26E-04*	*2.00E-03*	*1.00E-04*

Turning the focus to the emission costs per tonne of CO2 eq., SOx, NOx, PM emissions, average costs have been calculated based on Victoria Transport Policy Institute (2020) (Victoria Transport Policy Institute, 2020). The emission costs per tonne of pollutant that we assumed in this study is 90€/tonne of CO2eq., 6500€/tonne of SOx, 4700€/tonne of NOx and 2500€/tonne of PM2,5. The total emissions costs from the use of each fuel throughout the lifespan of the vessel can be seen in the following figure along with the CAPEX and OPEX for the respective period.

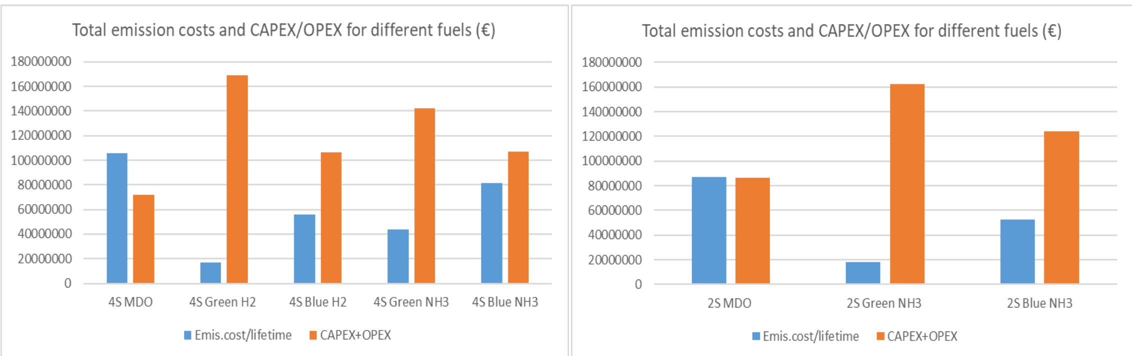

Figure 3: Total emission costs and CAPEX/OPEX for different fuels (€)

As can be seen in figure 3, for 4S engines the use of green hydrogen leads to the minimal emissions cost (external cost) compared to all other options accounting for 17 million euros, but is, at the same time, the most costly option with the total expenditure from its use reaching 170 million euros. Green ammonia represents the second best option in terms of external costs (44 million euros), but its use also leads to high CAPEX and OPEX (142 million euros) compared to conventional fuels. Following green hydrogen and ammonia, blue hydrogen comes third in terms of emissions cost (56 million euros) while blue ammonia comes fourth with an external cost of 81 million euros. Finally, as expected, the use of MDO generates a high external cost of 106 million euros and a low total expenditure of 72 million euros. The additional costs and benefits per kilojoule (kJ) from the use of hydrogen and ammonia as marine fuels throughout the lifespan of the vessel can be seen more clearly in figure 4.

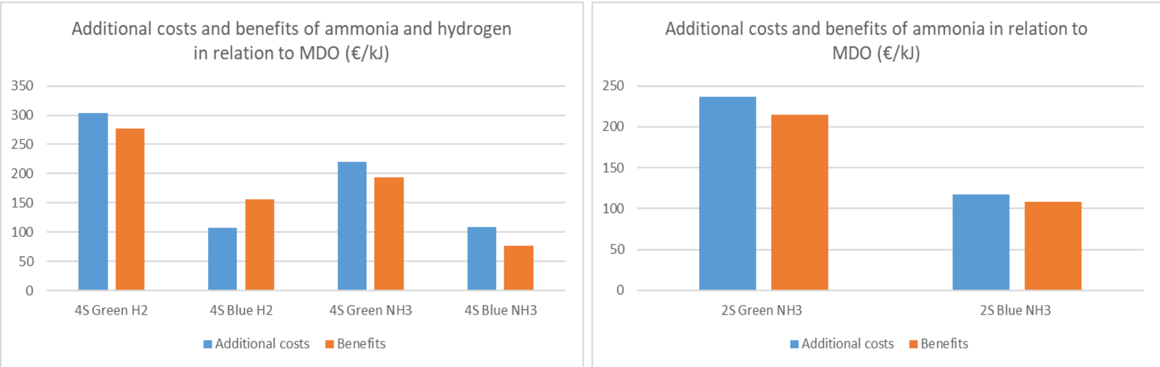

Figure 4: Additional costs and benefits of ammonia and hydrogen in relation to MDO (€/kJ)

The potential of ammonia and hydrogen to decarbonize shipping becomes quite obvious from the analysis undertaken in this research. Their life-cycle GHG emissions are far less than the ones generated from the use of MDO with the relevant external cost from their use also being minimal in comparison to conventional options. Besides their environmental benefits, though, the high total expenditure for their employment also becomes apparent underlining the urgent need to provide additional incentives to the industry in order to proceed with the necessary investments for the employment of alternative fuels and accelerate the energy transition of the sector. The introduction of market-based measures (MBMs) in the form of a global levy on marine fuel or an emissions trading system can internalize the external costs of conventional fuels and stimulate the employment of cleaner fuels by applying 'the polluter pays' principle (Wang et al., 2021; Christodoulou et al., 2021; Pomaska & Acciaro, 2022).

6. CONCLUSIONS AND POLICY IMPLICATIONS

This paper attempts to provide an assessment of the costs and benefits associated with the use of hydrogen and ammonia as marine fuels through a cost-benefit analysis in order to specify and underline the cost differences between these fuels and the conventional ones - especially MDO - and make policy recommendations on how this existing "cost gap" could be somehow alleviated through market-based measures (MBMs) to stimulate further investments on these fuels. Beginning with the cost assessment of the fuels, our analysis verifies the findings of existing literature that green hydrogen is by far the most costly option as marine fuel followed by green ammonia, blue hydrogen and blue ammonia. At the same time, though, the emission costs of green hydrogen (followed by green ammonia) are minimal compared to conventional – and even blue – fuels. Clearly, the use of renewable energy sources for the production of both hydrogen and ammonia is critical in order to achieve the decarbonization of shipping in the future.

The high total expenditure associated with the use of green fuels turns the introduction of MBMs - carbon taxes on marine fuels based on their GHG energy intensity or through the subsidization of renewable fuels, at least in the initial phase of their uptake - essential in order to alleviate the "cost gap" between these fuels and the conventional ones and accelerate the employment of cleaner fuels. Although the production costs of green hydrogen and ammonia are expected to decrease in the long run due to technical maturity and increased demand, for the time being their high CAPEX and OPEX in comparison with the cost of MDO represent the greatest challenge for their wide adoption by the industry.

Apart from the economic factors, additional challenges associated with the use of these fuels need to be addressed; indicative examples encompass safety concerns, regulatory aspects, restricted availability and an uncertain regulatory framework as different alternative fuels with GHG emission reduction potential have been proposed and considered for marine application. Safety concerns are quite often raised for the use of both ammonia and hydrogen for marine application due to their particular properties, the high explosivity of hydrogen and the corrosion and toxicity of ammonia. In this direction, the employment of ammonia and hydrogen as marine fuels is not allowed under the current IMO regulations and the relevant safety protocols need to be revised accordingly in order to proceed with the use of these renewable fuels. It should be mentioned here that not all renewable fuels are considered suitable for use for all maritime segments. Especially with regards to short sea shipping, electrification is gaining momentum for the decarbonization of short distances while the use of ammonia for passenger transport is not considered as a feasible option given the safety concerns associated with its employment as marine fuel.

At the moment, the production of renewable fuels is limited and the refueling infrastructure at ports for their employment is currently being developed with major ports around the globe building refueling facilities for the supply of several alternative fuels. Besides the IMO regulations and port initiatives, a number of shipping companies around the globe have already invested in alternative fuels ordering newbuildings with dual engines that can use both conventional fuel and ammonia (Christodoulou and Cullinane, 2021). Shipping industry coalitions can also play a critical role for scaling up the uptake of renewable fuels and accelerating the energy transition of the sector. Green corridors – an industry-driven initiative that seeks to create "specific trade routes between major port hubs where zero-emission solutions have been demonstrated and are supported" – can pave the way for the development of ecosystems 'with targeted regulatory measures, financial incentives, and safety regulations that can also put conditions in place to mobilise demand for green shipping on specific routes' (Getting to Zero Coalition, 2020).

7. ACKNOWLEDGMENTS

This research is part of the CAHEMA (Concepts of Ammonia/Hydrogen Engines for Marine Application) project funded by the Nordic Maritime Transport and Energy Research Programme (NMTERP) of Nordic Energy Research.

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ECOLOGISTICS - GOOD PRACTICES ON THE EXAMPLE OF POLAND

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Keywords: ecologistics, green logistics, renewable energy sources, European Union, Poland.

1. **ABSTRACT:** This article presents information on ecologistics, with particular emphasis on presenting this concept in the context of Poland. Based on the literature analysis, the definitions of ecologistics and green logistics were presented and the difference between these terms was indicated. The following part of the article describes Poland, one of the member states of the European Union. The solutions that Poland has implemented in the context of green logistics have been presented. The article presents a case study of ecologistics solutions that have been applied in various areas of logistics.

2. INTRODUCTION

Environmental pollution is a consequence of industrial and social development, as well as rapid population growth. These are the main problems facing humanity in the 21st century. On the basis of reports presented by international organisations concerned with, among other things, controlling the state of the environment or the impact of man and the economy on the ecosystem (e.g. UN, WHO or WMO report), one gets the impression that mankind has lost control over the process of environmental degradation and related climate change. This process of change is progressing and its effects, if not now then certainly in the next few decades, will change the face of our planet forever. The environmental crisis is not only about the current state of environmental pollution, but also about the projections that assume its deterioration, the probability of which is relatively high.

Development towards the Sustainable Development Goals depends on governments and multiple bodies consisting of public society organisations, private sector organisations and millions of people (Scharlemann, and others, 2020). A significant cause of global warming is greenhouse gas emissions (Ahmed and others, 2021d). Over the years, CO2 emissions have received much attention in the literature as a measure of pollution (Zhang and others, 2021). A report published by the World Meteorological Organisation (WMO, World Meteorological Organization) in March 2019 shows that the physical signs and socio-economic impacts of climate change are accelerating. Record concentrations of greenhouse gases are causing global temperatures to approach increasingly dangerous levels. The WMO also points to record sea level rise, as well as unusually high increases in land and ocean temperatures. The organisation confirms that the described warming trend has continued since the beginning of the current century and is expected to continue (WMO, 2019).

The climate agreements that most of the world's countries are ratifying are a significant global manifestation of humanity's concern for the environment. The international community is now focusing on the pursuit of green growth. Scientists, too, are noticing the increasing impact of the environment on all decision-making areas in logistics and are advocating the need to adapt logistics processes to changing conditions, such as the climate crisis and restrictions on access to natural resources). In today's fast-paced and interconnected world, logistics plays a key role in the movement of goods and services, and the logistics sector plays a key role in the economic development of any country. However, given the growing emphasis on sustainability, the high levels of energy consumption and carbon emissions in the logistics sector do not support the sustainability of logistics. Companies are forced to increase productivity while using efficient and sustainable resources to eliminate environmental destruction. Green logistics, which is a holistic approach to logistics management that considers the environmental and economic implications of logistics operations, has emerged as a solution to these challenges. As such, green innovation, the supply chain loop, economic globalisation and the use of renewable energy are becoming increasingly popular.

The aim of the article is to present an in-depth analysis of green logistics practices in Poland, including the current state of these practices, the role of government and industry, and the impact of consumer behavior on their functioning. The article used both theoretical and practical research methods. The research involved a multifaceted approach that combines several methods to gather information and analyse the current state of ecological science in Poland.

The article provides a comprehensive review of existing literature and research on green logistics. The review was conducted to gather background information, identify knowledge gaps and understand the current state of green logistics practices and their impact. The literature review included academic journals, reports and industry publications.

Case studies have been used to provide a practical understanding of how green practices can be implemented. The case studies will provide a comprehensive understanding of the current state of green logistics practices, the challenges faced by the logistics industry in transitioning to sustainable practices and the role of government and industry in promoting green logistics initiatives.

3. THEORETICAL FRAMEWORK OF ECOLOGISTICS

Logistics can be defined as the management of an organisation's inventory, the transportation of goods, purchasing and the flow of information through its marketing channels to increase revenue (Christopher, 2016). Logistics has become the backbone of the global economy, driven by both consumption and production. Logistics occupies a significant position in a country's economic growth and development, but also increases air pollution, including greenhouse gases. Consequently, initiatives in the area of the so-called green economy are playing an increasingly important role in today's world. Green development means choosing a strategy for the operation and functioning of all structures in such a way as to combine environmental protection with all other functions of the economy. Ecology in logistics should prevent the negative effects of the functioning of logistics systems mainly in the production, transport and storage of physical goods (Korzeń 2001).

In order to properly understand the issues of environmentalism, it is necessary to define the concept and define its area. In theoretical terms, environmentalism is a sub-area of ecology-oriented logistics. Initially, environmental science was mainly concerned with the collection, treatment and disposal of waste. In this view, environmental science is concerned with research and activities related to the implementation of optimal solutions for the collection, gathering, disposal and routing for utilisation or environmentally and socially unobtrusive disposal of various types of waste (Korzeniowski and Skrzypek 1999). Nowadays, the term describes a much broader meaning, understood primarily as the subordination of logistical strategy to environmental objectives.

The concept of ecologistics is becoming more and more popular in Poland, but it should be noted that it is understood differently and covers other topics than in the international arena. In the English-language literature, ecologistics is a rarely encountered concept. In the world, the most commonly used terms are green logistics, but also: reverse logistics and waste logistics. In Poland, these three terms coincide with the definition of ecologistics. Based on the foregoing, these terms will be used interchangeably.

Ecologistics, seen as a group of logistics activities, is aimed at reducing the negative impact of physical and information flows on the environment. It is a concept combined with green logistics. Green logistics is an idea that stimulates pro-environmental strategic, operational and organisational solutions, into which ecologistics also fits (Baraniecka, 2019). The definitions of ecologistics and green logistics developed over the years are presented in Table 1.

In the modern world, the concept of ecologistics can be considered in terms of two criteria - economic and ecological. The economic consideration stems from the actual essence of logistics and is aimed at reducing the costs of logistics processes in terms of waste flows by using them efficiently or preventing them from occurring. These activities are also concerned, through waste prevention, with increasing product profitability and increasing demand for the products of the company in question, which directly increases revenues.

The ecological aspect in the context of ecologistics, on the other hand, is concerned with protecting natural resources and reducing emissions generated during logistics processes. These activities should focus primarily on the adaptation of the operators' activities to existing legal regulations and social norms.

Green logistics is one of the elements that can lead to achieving the targets of sustainable development. By lowering the operating costs of companies and saving energy without harming the environment and society, while increasing the quality of life of society, green logistics fits into the tenets of sustainable development (Karia and Asaari, 2016).

Table 1. List of definitions of ecologistics

Ecologistics is an integrated system which: is based on the concept of managing recirculating flows of streams of waste materials in the economy and the flows of information coupled with them	Korzeń 2001

Green logistics is the management of the flow of knowledge, materials and funds between institutions whose goal is growth with an emphasis on social and environmental sustainability, while paying attention to the requirements of all stakeholders	Seuring and Müller, 2008
It's green supply chain management that you can define as an organization's activity that takes into account environmental issues and integrates them with supply chain management	Lee and Klassen, 2008
Applying the concept of logistics to residues in order to reduce their formation, including (very importantly) preventing their formation and inducing their economically and ecologically effective flow, with simultaneous spatial-temporal transformation, including a change in quantity and species	Baraniecka, 2019
The term "green logistics" is defined as supply chain management practices and strategies that reduce the environmental and energy footprint of goods distribution, which focuses on material handling, waste management, packaging and transportation	Rodrigue, Slack and Comtois, 2012

The current state of green logistics practices is a rapidly growing field that has attracted increasing attention from both the public and private sectors in recent years. This growth is driven by a growing awareness of the negative environmental impact of traditional logistics practices, as well as a growing demand for environmentally friendly products and services.

Green logistics practices cover a wide range of activities, including the use of renewable energy sources, efficient transport methods and the reduction of waste and emissions. These practices have been shown to have a positive impact on the environment, including reducing greenhouse gas emissions, conserving natural resources and reducing waste.

In terms of economic impact, green logistics practices have been shown to have both direct and indirect benefits. For example, the implementation of green logistics initiatives can lead to lower operating costs, improved efficiency and increased competitiveness of logistics companies. In addition, the growing demand for environmentally friendly products and services creates new business opportunities and drives economic growth in the green logistics sector.

4. GENERAL OVERVIEW OF POLAND

Although scientific research and reports prepared by governmental and non-governmental organisations emphasise clear progress, the practice of environmentalism in Poland cannot be considered advanced. On the basis of the research results, it should be pointed out that the main barrier to the implementation of ecological solutions in the field of logistics is the expected high costs, as well as the identified low competence in the implementation of pro-ecological investments. Barriers most often arise as a result of low ecological awareness among enterprises, as well as a low appreciation of the fact that one's actions can actually have an impact on the environment. These barriers, are relatively easy to eliminate, e.g. by introducing management solutions in the form of decision-making models and algorithms, organisational solutions and changes in human resource management.

Although climate change occurs and is considered on a global scale, it is important to remember that very often its origins can be traced to the local area. This is why most countries in the world, regardless of their membership of various international organisations, monitor their own environmental state.

Poland is situated in the centre of continental Europe. The capital city, Warsaw, is located in central-western Poland. Other large cities include: Krakow, Poznan, Lodz, Wroclaw, Gdansk and Rzeszow. 1 Poland's extensive natural resources include particularly abundant deposits of hard coal, exploited in the mines of Upper Silesia, and brown coal extracted mainly through the open-cast method. Deposits of copper, sulphur and zinc-lead ores, and other minerals such as rock salt are of major economic significance. Poland also has substantial quantities of geothermal water and mineral waters (Eurostat). Poland, with a surface area of 312685 km 2 , is the ninth largest country in Europe. Poland borders the Russian Federation (Kaliningrad District), Lithuania, Belarus, Ukraine, Slovakia, the Czech Republic and Germany. On date 22 June of 2022 total amount of population in Poland is: 37 840 001. Poland is ranked 5th among the European Union countries (Eurostat). GDP and main components (output, expenditure and income) on 09.01.2023 Poland have: 574 771.8 mln. EUR. Real GDP per capita on 09.01.2023 amount : 13 760 mln. EUR. Poland is the 8th biggest economy in the European Union, yet GDP per capita remains significantly below the EU average. The country's industrial base combines coal, textile, chemical, machinery, iron, and steel sectors and has expanded more recently to include fertilizers, petrochemicals, machine tools, electrical machinery, electronics, cars and shipbuilding. On the expenditure side, household consumption is the main component of GDP and accounts for 60 percent of its total use, followed by gross fixed capital formation (20 percent) and government expenditure (18 percent).

Socio-demographic changes and economic growth are causal factors influencing the state of the environment. Development without respect for the environment would result in the overexploitation of natural resources and increased emissions of pollutants. In view of this, the current concern for the environment and its resources, manifested within the framework of the idea of sustainable development and the concept of a green economy, is therefore most justified.

The resilience of the environment and its capacity to regenerate is limited. It is assumed that in order to ensure sustainable development in the long term, countries must be characterised simultaneously:
• an ecological footprint of less than 1.8 gha (so-called global hectares) per capita,
• Human Development Index higher than 0,8.

The HDI index can measure a country's level of social development in relation to other countries, both at a given point in time and over a longer period. Poland, with an index of 0.85, is among the highly developed countries.
The ecological footprint, on the other hand, shows how much space on Earth, including land and sea, each of us consumes. Our use of natural resources in the broadest sense is compared with the planet's capacity to regenerate them. When human needs exceed the capacity of the environment, there is an ecological deficit. Poland's ecological footprint was in 2018. 4.8 gha per person. Although this is clearly less than in the 1980s, and historically an upward trend alternates with a downward one, it is still 0.5 gha more than in 2000. Meanwhile, the biological potential remains at a similar level of around 2 gha per person. We consume 2.5 times more than our environment can reproduce. Poland, compared to other EU countries, is not isolated in this case. If everyone on Earth lived as Poles do, humanity would need 3 planets not to incur a so-called ecological debt (Stan Środowiska w Polsce, Raport 2022).

So what is the solution?

The article goes on to present examples of the implementation of greening and the use of green solutions in various areas of Poland's functioning.

5. EXAMPLES OF GOOD PRACTICES IN POLAND

Adopting the right lines of intervention requires constant monitoring of progress. In the case of Poland, the actions taken related to clean energy and green logistics are mainly the result of legal regulations imposed by the European Union. In 2020. The EU adopted 'A new EU Circular Economy Action Plan For a cleaner and more competitive Europe'. It covers, among other things, the issues of extending so-called eco-design, extending the life of products and guaranteeing reparability, introducing digital product passports, increasing high-quality recycling. It points to the need to "close the loop" in 7 key areas: plastics (including an end to microplastics), textiles (highly material- and water-intensive with only 1% recycled in the EU), electronics and ICT (the fastest growing waste stream in the EU), food, water and nutrients. According to the EU's farm-to-table strategy by 2030. food waste per capita is to be halved by 2030 (European Commission), packaging (all to be reusable or recyclable by 2030), batteries and vehicles (e.g. reducing carbon footprint), buildings and construction (e.g. material and energy efficiency) (Stan Środowiska w Polsce, Raport 2022).

5.1 Waste management

It is undoubtedly necessary to reduce the negative human impact on the environment, including the consumption of the Earth's resources in the broadest sense. It is not only about reducing consumption, but also about greater efficiency in the use of resources and the so-called closing of the economy in circulation. In the simplest terms, this is the longest possible use of the value of raw materials, materials and finished products. In practice, this primarily involves using, repairing, renewing, reusing, as well as borrowing and sharing for as long as possible. On the other hand, in the case of waste generation, recycling and, in particular, recovery.

The mass of municipal waste generated in Poland is gradually increasing. In 2021, it was 360 kg per Polish inhabitant on average. However, this is one of the lowest values in the EU, where a statistical inhabitant generates 505 kg (data for 2020) of waste per year (Stan Środowiska w Polsce, Raport 2022).

The recycling rate of municipal waste in Poland has increased - from less than 18% in 2010 to approximately 27% in 2021. In order to monitor the treatment of municipal waste in the European Union, the rate of preparation for reuse and recycling of municipal waste is analysed. Its value has also increased, from 24% in 2013 to 41% in 2020 . For all waste generated, of which mining and quarrying is the main source (57%), less than half (47.5%) was recovered and less than 44% was landfilled. New challenges are emerging in waste management. For example, the growth of e-commerce, especially used during pandemics, is causing an increase in packaging waste (Stan Środowiska w Polsce, Raport 2022).

As the Institute for Innovation and Responsible Development INNOWO points out, of all materials and raw materials used in the Polish economy - from metal ores and non-metallic minerals to biomass and fossil fuels - 10.2% are recirculated. This is above the global average (8.6%), but it also means that the so-called circularity gap in the Polish economy is close to 90%. It should be emphasised here that even Scandinavian countries such as Sweden and Norway, associated with many ecological solutions, fare much worse in the comparison (3.4% and 2.4% respectively) (Stan Środowiska w Polsce, Raport 2022).

5.2 Consumer behaviour

The attitudes and moods of consumers towards broadly understood ecology are constantly changing. Poles are more and more aware, and thus, more often pay attention to what they buy and whether what they buy is eco. In the research of the Ministry of Climate and Environment on the awareness and ecological behavior of the inhabitants of Poland, 86% of respondents indicated that they are willing to limit the purchase of material goods in order to preserve natural resources and reduce the amount of waste generated (Stan Środowiska w Polsce, Raport 2022).

The survey was carried out on March 2-9, 2020 by SW RESEARCH, the Market and Opinion Research Agency, using the online interview method. As part of the study, 847 surveys were conducted. Among the most popular forms of ecological promotion, the change of product packaging was most often indicated (76%) and the use of ecological icons/symbols (72%). In second place, the use of BIO / ECO names was mentioned - over 60% of the respondents encountered this form of promotion. surveyed. According to the respondents, agriculture, animal husbandry and plant cultivation most often use the communication of elements of ecology (40%). The high score can be explained by the growing trend for organic, non-modified food. The second position in the eco-ranking of industries was taken by beverages and water (37 percent of responses), and the third place was taken by the beauty industry (32 percent), related to the production and cosmetic services. Such high indications for the listed industries may be significantly influenced by consumer associations related to the increasingly common use of new, more ecological packaging, ecological symbols and icons, and the use of ECO and BIO labels, resulting partly from the need to meet standards and legal requirements, and partly from purely marketing and promotional activities (https://www.horecanet.pl)

5.3 Renewable energy sources

Renewable energy can help restore energy security and focus on the challenges of climate change. Using and supporting renewable energy sources can help reduce pollution and minimise dependence on fossil fuels (Rahman and Alam, 2022). Climate change experts believe that renewable energy sources have long been known for their ability to reduce CO2 emissions as well as create more environmentally friendly circumstances.

In Poland, the sector with the largest direct energy consumption is industry (approx. 35% in 2020). This is followed by transport (c. 27%) and households (c. 23%) with a significant share (State of the Environment in Poland, Report 2022). Transport therefore accounts for a significant share of greenhouse gas emissions in the EU.

Based on data provided by Eurostat, it is possible to observe the share of renewable energy sources used in transport in EU member states since 2004. The common target set for all EU countries for 2020 is at least a 10% share of renewable energy in transport. Analysis results presented by Eurostat show that the average share of renewable energy in transport has increased from 1.6% in 2004 to 10.2% in 2020. This represents 0.2 percentage points above the target level. Figure 1 illustrates how the target has been achieved.

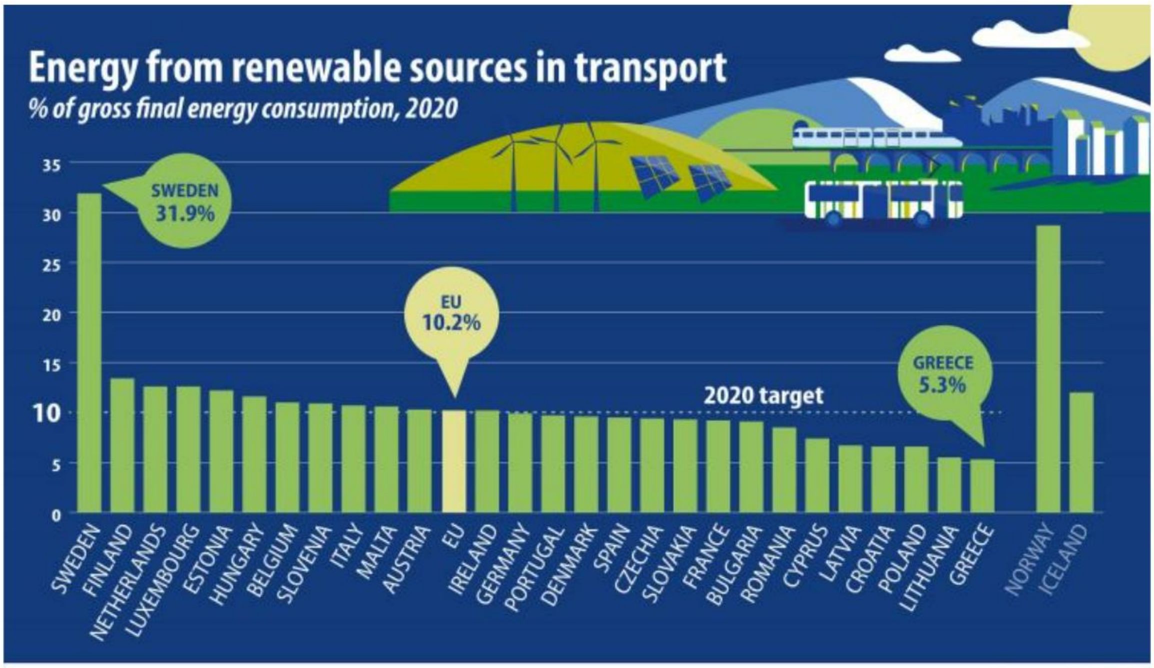

Figure 1 Energy from RES in transport

Source : https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220202-2 accessed Nov. 24, 2022

However, it should be emphasised that each Member State set individual national targets for the use of energy from RES. Poland set its target at 6%, and therefore joined the group of EU countries that successfully achieved their targets in 2020.

The share of renewable energy in energy consumed in transport is calculated by dividing the value of renewable energy consumption in transport by the total value of energy consumption in transport. The share of renewable energy in fuel consumed in transport is one of the indicators monitoring progress towards the target of increasing the share of energy from renewable sources in the EU.

The main source of RES for transport is biofuels including liquid biofuels, which are produced from feedstocks of organic origin (from biomass or biodegradable waste fractions). Natural vegetable oils can also be used as liquid biofuels. These products are used as bio-components added to motor fuels made from crude oil. The most commonly used additives are bioethanol (an additive for petrol) and biodiesel (an additive for diesel).

The European Union's climate neutrality plans up to 2050 include the need to reduce emissions in transport not only through the use of RES. Cars and vans currently produce 15% of the EU's CO2 emissions. Road vehicles are the most emitting. They are responsible for more than 70 per cent of greenhouse gas emissions from transport in the EU. In 2018, emissions from road transport amounted to 786 million metric tonnes of carbon dioxide equivalent - a 27 per cent increase since 1990. CO2 reduction targets for 2030 are 37.5 per cent for new cars and 31 per cent for delivery vans.

Between 2010 and 2018, the amount of carbon dioxide produced on average by new passenger cars registered in Poland decreased by 12%. In order to both reduce greenhouse gas emissions and improve air quality and reduce noise exposure, electromobility is being promoted in Europe. Part of the EU's "Fit for 55" programme (europa.eu), published in 2021, is a ban on the registration of new cars with internal combustion engines from 2035. In Poland, by mid-2022, newly registered low-emission cars accounted for almost 40% of the market. The number of electric cars is growing rapidly. By mid-2022, there were more than 50,000 such cars (the share of all-electric cars and plug-in hybrids is almost equally distributed). Their number increased by 45% in one year. At the same time, the rapid transition to electrically-powered cars may lead to the need for a surge in electricity production. Providing appropriate charging infrastructure also remains a challenge. The transition to electric cars also requires a major change in consumer behaviour, due to the time needed to charge the battery, the availability of stations and heated garages.

6. CONCLUSIONS

Globally, in the last 50 years, the production of goods has doubled, the extraction of raw materials has tripled and the level of economic development, as expressed in gross domestic product, has quadrupled. We are therefore witnessing an ever-increasing demand for materials. As the European Environment Agency points out, this increase in human activity is a dominant cause of biodiversity loss and increased water stress, a significant source of greenhouse gas emissions and a source of pollution.

The complexity of the relationship between human activities and the state of the environment, global trade links and the planet's limited capacity and "resilience", challenges the country's economy to reconcile the needs with the supply of environmental goods and services, and to reconcile its protection with an increase in the quality of life. Limiting consumption is not easy. Its growth is strongly linked to economic development and changes in society.

The energy transition, associated with the development of RES and electromobility, poses a number of challenges and requires consideration of the interrelationship between elements of the environment and human activities, related, inter alia, to energy sources, energy storage and transmission, materials used and waste generated. The initiatives implemented in Poland to develop RES and increase energy efficiency are in line with the idea of a closed loop economy. The growing problems of energy supply in Poland and across Europe will have their impact on environmental policy.

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ENVIRONMENTAL IMPACT OF MARITIME LOGISTICS USING SATELLITE DATA

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Keywords: Satellite data, ship detection**,** eutrophication assessment, geospatial portal, methodological framework.

1. **ABSTRACT:** Shipping continues to have a negative impact on the marine environment, contributing among others to eutrophication through NOx emissions. Today, ship detection is considered a key aspect of maritime surveillance, as it enables the monitoring of various maritime activities, such as maritime traffic, search and rescue, cargo transportation, maritime defense, illegal fishing, and also includes environmental aspects, such as environmental assessment of adverse effects, and oil spill detection and monitoring. In this context, paper presents a methodology that aims to collect, process, and analyse data on a large temporal and spatial scale for the assessment of environmental impacts due to maritime traffic, using satellite data. Data of ship detection and nutrients related to the phenomenon of eutrophication are used for the assessment. Both datasets are collected, stored and visualized through a developed geoportal, accessible by multiple users, providing download and visualization services. Geospatial portal is expected to provide access to high-resolution and easily understandable spatial data to a large group of people, scientists, decision makers and other interested parties.

2. INTRODUCTION

The phenomenon of marine eutrophication is the most common environmental problem that contributes to the degradation of the quality of coastal ecosystems and the marine environment by excessively increasing phytoplankton and phytobenthos [1,2,3]. When nutrient enrichment of waters does not come from human activities, eutrophication is a natural process. This process is influenced by various factors such as coastal upwelling, sediment resuspension and atmospheric deposition of nutrients through precipitation [4]. However, it seems that shipping contributes to the eutrophication through the NO_x emissions [5].

Vessel detection, as a part of maritime surveillance, is considered very important and plays a critical role in port management as well as environmental protection, in relation to maritime traffic, search and rescue, cargo transportation, maritime defense, illegal fishing, and oil spill detection and monitoring [6.7]. Today, maritime surveillance can be implemented using a variety of methodologies and tools, using either cooperative systems (in which vessels report their identity and position, together with information derived from other onboard systems), such as the Automatic Identification System (AIS), Long Range Identification and Tracking (LRIT) and Vessel Monitoring System (VMS), or non-cooperative systems, which do not demand any action from the ships. The latter typically use cameras or radars installed on platforms (e.g. satellites, etc.). It is also notable that, while AIS is widely used, the other two cooperative system options are not particularly widespread and consistently available at global level.

Ship detection using Sentinel 1 Synthetic Aperture Radar (SAR) data is included in non-cooperative systems and allows the tracking of ships that may not require AIS or similar systems (e.g. small-scale fishing vessels), or vessels involved in illegal activities (piracy, illegal and unregulated fishing, etc.) [8]. In addition, SAR images have the advantage of being independent of weather, thus enabling detection on a regular basis. SAR data is also used to detect vessels in extreme weather conditions and storms for search and rescue purposes [6, 8].

This paper proposes a methodology that aims to collect, process, and analyse data on a large temporal and spatial scale for the assessment of environmental impacts due to maritime traffic, using satellite data. The rapid development of remote sensing as well as the free availability of satellite data and other related products to the scientific community contribute to this objective. Section 3 describes the overall methodology. Section 4 presents the geospatial portal in which the datasets of ship detection and nutrients related to the phenomenon of eutrophication are collected stored and visualized, taking advantage of the possibilities provided by the satellite data use and data of the World Wide Web. Conclusions, findings and future research steps are summarized in section 5.

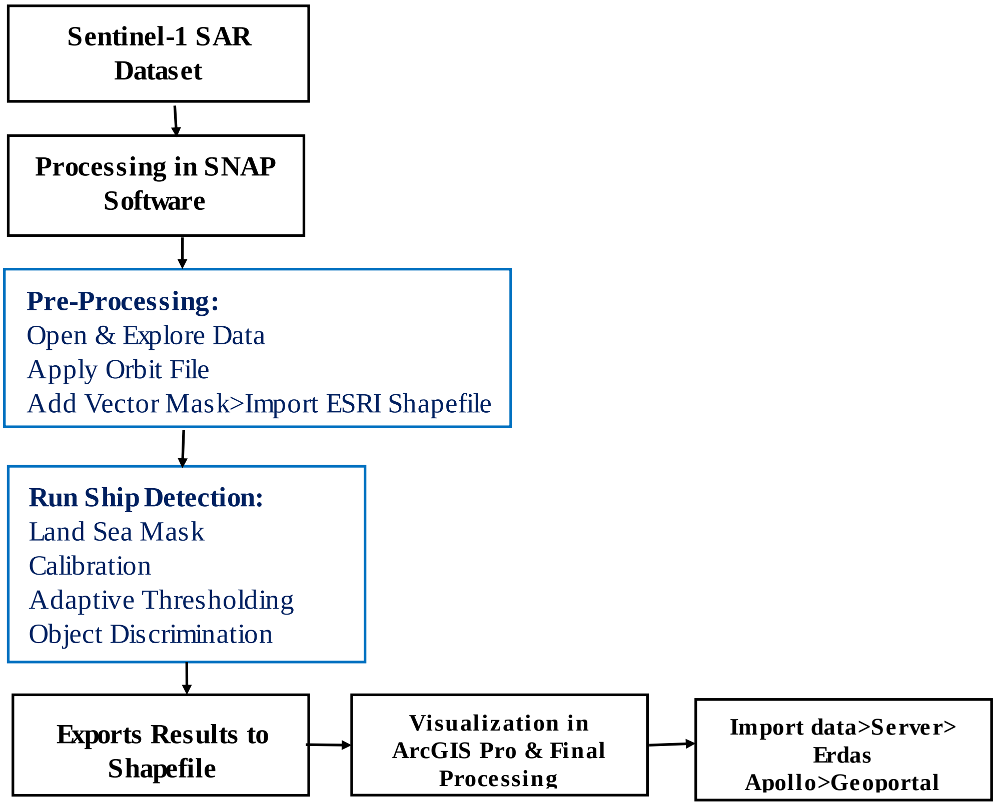
3. METHODOLOGICAL FRAMEWORK FOR ENVIRONMENTAL ASSESSMENT USING SATELLITE DATA

The methodology followed includes the processing of satellite data both for the detection of ships and the spatial distribution of nutrients in the marine environment. The processing steps are detailed below.

3.1 Tools and data for ship detection

This subsection describes in detail the proposed methodology for ship detection using Sentinel-1 SAR data. The whole process from obtaining the required data to visualizing the results is shown in Figure 1.

Sentinel-1 C Band SAR images for the area of interest (AoI) were obtained from Alaska Satellite Facility (ASF) [9], with the following characteristics: beam mode: IW[3], polarization: VV+VH[4] and flight direction: descending. Thirty images were downloaded, fifteen of each frame, all level 1-Ground Range Detected (GRD), from July 01 to December 31, 2021 (Figure 2). The software used is SNAP 9.0.0. Both satellite images and SNAP software are freely available to any user from ASF and the European Space Agency (ESA) through Science Toolbox Exploitation Platform (STEP) [10] respectively. The following paragraphs describe the overall methodology in the SNAP software and further manual processing.



[3] IW: Interferometric Wide
[4] VV: vertical transmit, vertical receive; VH: vertical transmit, horizontal receive.

Figure 1. Methodology Flowchart

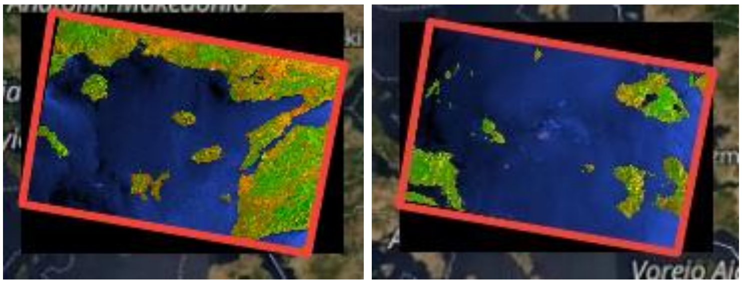


Figure 2. Area of Interest (AoI): A&B Frame. North Aegean Region (Greece).
Source: Alaska Satellite Facility [9].

Pre-Processing: Pre-processing is considered necessary for Sentinel-1 IW Ground-Range Detected High Resolution (GRDH) products, as they usually have some issues with their orbit information in the metadata. Orbit information included in the metadata of SAR images is usually not precise and can be improved with accurate orbit information available several days after the creation of the product. To address this issue, these products need to be updated with recently available orbit files that provide precise information about the satellite's position and speed. This process is called "Apply orbit file". As part of the pre-processing is also the creation of a vector mask. This mask is used as a layer to the area of interest and covers the land area, in order to avoid detecting false targets (vessels) on land. Although, the software provides a default "Shuttle Radar Topographic Mission (SRTM) 3sec Digital Elevation Model" option to mask out areas with positive elevation, it is not preferable, as it sometimes detects false targets, particularly in complex coastlines such as AoI. The main process for ship detection consists of the following sub-stages:

- Land-Sea-Mask: In this step, the already loaded vector mask is used (as discussed above).
- Calibration: Radiometric calibration is applied. Although, uncalibrated SAR images are considered adequate for qualitative purposes, calibrated SAR images are necessary to quantitative use of SAR data [8].
- Adaptive Thresholding: This method is considered very common for ship detection in SAR images. Software applies a Constant False Alarm Rate (CFAR) approach, as a specific type of this method. The general idea is that targets are displayed brighter compared to the surrounding darker area.
- Object Discrimination: In this final stage, the minimum and maximum size limits are set to avoid false target detections. 20m and 600m (default value) were respectively set for minimum and maximum size limit, which means that targets with dimensions larger or smaller than these thresholds are rejected [8].

In order the results from SNAP software to be more manageable and can be further processed and visualized in a Geographic Information System (GIS) software, such as ArcGisPro, they are exported to an ESRI shapefile. In ArcGisPro environment, all files are unified into six individual files, one for each month (i.e.: from July to December) (Figure 3).

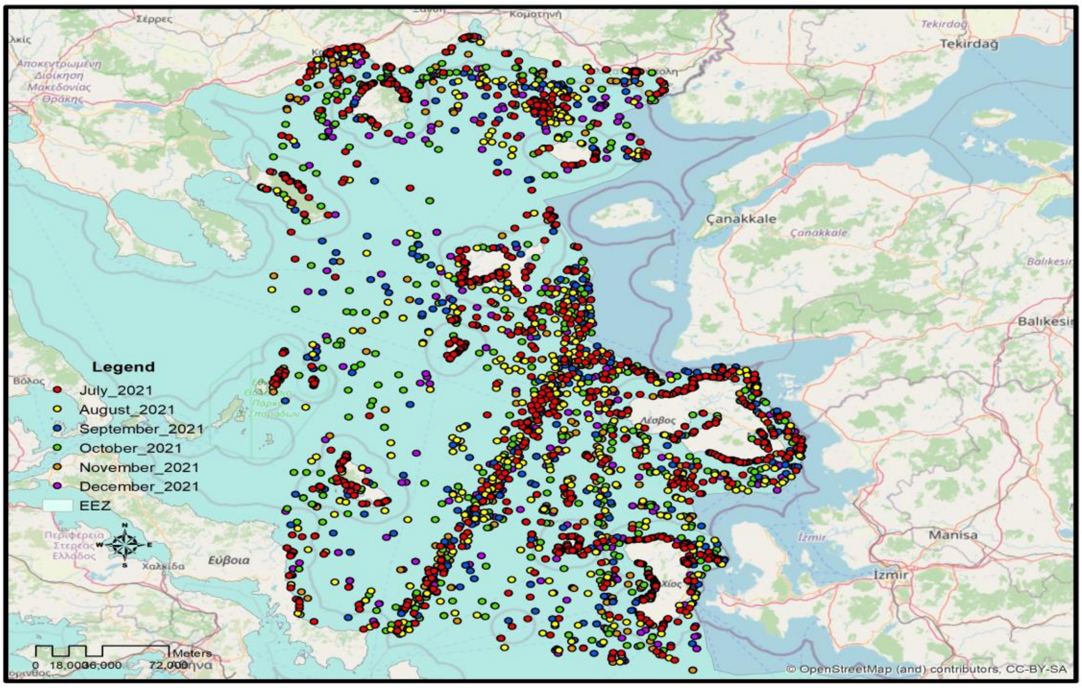


Figure 3. Visualization of final results for AoI in ArcGisPro environment.

3.2. *Data for eutrophication level assessment*

The data used were derived from the Marine Copernicus database for the years 2012-2021 and are L4 processing level data, namely: satellite measurements of surface chlorophyll *a*, as well as numerical model products of variables related to marine eutrophication. Data pre-processing is necessary to enable the calculation of monthly and seasonal eutrophication values. This includes a) the conversion of the data structure from Network Common Data Form (NetCDF) to ArcGIS Raster, b) the conversion of the data into a common coordinate system (EGSA'87[5]) and finally, c) the conversion of the spatial analysis of the data. Then a geodatabase was developed in a GIS environment for the period 2012-2022 consisting of average monthly concentrations of chlorophyll *a* (chl *a*, μg/L), nitrates (N-NO_3, μmol N/L), ammonium (N-NH_4, μmol N/L) and phosphate (P-PO_4, μmol N/L).

[5] EGSA'87: Greek Geodetic Reference System

4. DEVELOPMENT OF THE GEOSPATIAL PORTAL

The renewed web client of Erdas Apollo by Hexagon, the Catalog Explorer is used to catalog and deliver the geodatabase. Erdas Apollo provides a geospatial portal that stores, distributes, edits and downloads large volume of geospatial information. The spatial data infrastructure can be regularly updated and deliver into any client, on any device (Figure 4).

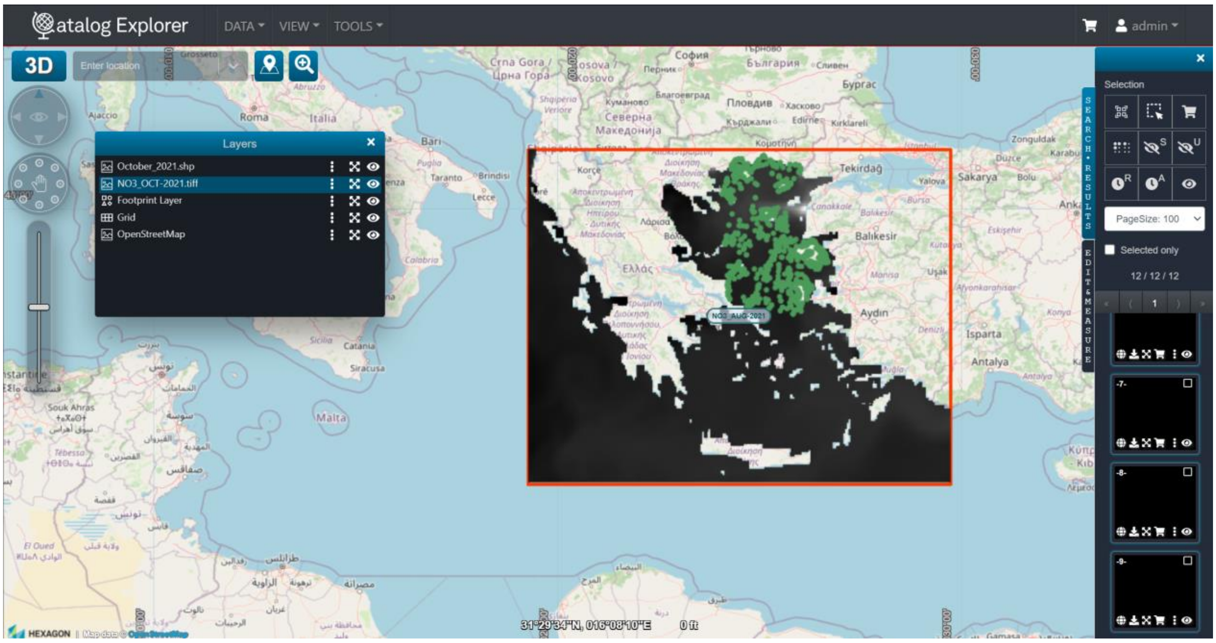


Figure 4. Geospatial portal interface where are selected to visualized the (a) concentration of nitrates and (b) the shipping detection for the October 2021.

5. DISCUSSION

The methodological framework presented in the article can serve as a tool for maritime/environmental policy in the long term. In particular:

- TSS (Traffic Separation Scheme) can be redefined to avoid problems of marine collisions in environmental sensitive areas, which are the main cause of accidents;
- Support the management of environmental risks in sensitive areas with increased shipping traffic;
- By processing data from the method it is possible to issues specific guidelines on ship operation (e.g. non discharge of liquid waste) to avoid polluting the areas;

- The maritime pollution response network (emergency stations) can be revised using data from maritime traffic and provide real time awareness of any environmental accident.

6. CONCLUSIONS

The assessment of seawater quality is of major importance and a prerequisite for decision-making and management of marine areas and the coastal zone. In this context, satellite images that visualize the spatial distribution of nutrients prove to be particularly useful as they contribute to the assessment of the phenomenon of eutrophication, which is one of the most important causes of marine water pollution.

Shipping continues to have a negative impact on the marine environment, contributing among others to eutrophication through NOx emissions. In this framework, satellite images and freely available softwares such as SNAP software can provide precise location of ships, regardless of weather conditions and coverage limits, to assess these adverse impacts.

Ship detection and nutrients datasets related to the phenomenon of eutrophication are collected, stored and visualized through a developed geoportal. The entire data infrastructure can be regularly updated and delivered to any client, on any device. As a result, decision-makers have an online tool with which they can combine visualized data on ship position and marine eutrophication levels. This tool can assist in adoption of strategies and more generally policies related to the maritime traffic and conservation and restoration of the environmental quality of the sea.

Future research includes the integration of a geoprocessing tool to assess eutrophication levels and visualize the spatial distributions of eutrophication levels, as well as the integration of a T-AIS dataset in order to compare/correlate AIS data with that obtained after processing from satellite SAR data. This comparison aims to double check and identify vessels that may not transmit AIS due to illegal activities. Finally, a Web Map Service (WMS) will be provided by the geospatial portal providing information on shipping density and covering a period from 2017 to 2021. Through geospatial portal, it is expected that a large group of people, scientists, local authorities, decision-makers and management as well as other involved groups will have access to high-resolution and easy-to-understand spatial data.

7. ACKNOWLEDGMENTS

This research is part of the Action "e-Aegean-Geo-spatial data services" funded by the Research e-Infrastructure "[e-Aegean R&D Network] R&D Network in Aegean Archipelagos: Supporting Regional Innovation, Entrepreneurship and Excellence" {Code Number MIS 5046494} which is implemented within the framework of the "Regional Excellence" Action of the Operational Program "Competitiveness, Entrepreneurship and Innovation". The action was co-funded by the

European Regional Development Fund (ERDF) and the Greek State [Partnership Agreement 2014–2020].

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Foundations for the sustainability of the LNG supply chain in Egypt and the logistics services supporting it.

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ABSTRACT:

Natural gas has recently become the preferred fuel for many countries at the global level, whether rich or poor, due to its relatively low price and the lack of harmful emissions to the environment resulting from it compared to oil and coal, as the proportion of carbon dioxide in natural gas is 30% less than oil and 45% less than Coal and therefore the major countries in Europe and America depend on it in many fields, whether in industry, power generation or heating. The major industrial countries in Europe and America face a major problem in their natural gas reserves due to the Russian-Ukrainian war and the suspension of Russian gas supplies to Europe in Nord Stream pipelines 1 and 2. Accordingly, Egypt seeks to become a regional center for the production, liquefaction and export of gas in the Middle East, especially after the discovery of the Zohr field and the realization of a surplus in natural gas production. the study seeks to demonstrate the foundations for the sustainability of the LNG supply chain in Egypt and the logistics supporting services it, starting from the places where it is extracted to its export or consumption, especially in light of the global trend towards preserving the environment, reducing emissions, using environmentally friendly energy sources and achieving environmental sustainability standards.

Keywords: liquefied natural gas - supply chains – Transportation - sustainable development – logistics services

1. INTRODUCTION:

Recently, natural gas has become of strategic importance in the global political economy and has a strong influence in international relations, as it gives the producing and exporting countries that possess high reserves of natural gas economic and political weight, as natural gas is considered one of the most important sources of energy and is used in many activities such as Industry, heating, etc. Thus, the world is now facing an increasing consumption of natural gas because it is less polluting the environment compared to other sources of energy such as coal and oil, which led to a significant expansion of gas trade worldwide and increased interest in studying the natural gas supply chain and the logistical activities involved in it, including extraction, storage or Transportation and distribution, whether from producing countries to consumers from neighbouring countries, or to consuming countries far from the sources of production, with the aim of raising the efficiency of these activities and reducing their costs in order to achieve significant economic savings. Sangaiah, et al., (2019)

The capabilities of the countries of the world differ in the production of liquefied natural gas, and the volume of natural gas consumption by the countries of the world differs for several factors, including the population represented in the domestic consumption of natural gas, especially in Europe in very cold regions for heating, in addition to the size of the industry, and the volume of transport activity, and other areas of liquefied natural gas consumption Natural gas production is concentrated globally in several regions, including Asia, the Pacific, the Middle East, and African countries, including Egypt and America, in addition to Russia, Norway, and other sources of LNG production and supply. LNG is stored in floating units, which are LNG vessels of varying tonnage and carrying capacity. Merkulov et al., (2020)

The following figure reviews the volume of natural gas production in Egypt and the volume of domestic consumption of natural gas, as Egypt possesses approximately 65 trillion cubic feet (1.84 trillion cubic meters) of proven natural gas reserves in 2016, thus Egypt ranks fourth in Africa in the level of gas production After Nigeria, Algeria and Mozambique, more natural gas fields are expected to be discovered in the coming years, which will contribute to raising Egypt's production of natural gas and it caused an increase in domestic demand before the discovery of the Zohr and Atoll field. Egypt also seeks to develop the natural gas fields that were discovered, such as the Zohr field, Atoll field, and the West Nile Delta project. The Zohr field is considered the largest marine natural gas field discovered in the Mediterranean, given that it contains reserves estimated at about 30 trillion cubic feet, which contributes to Egypt's aspirations to achieve self-sufficiency. of gas, meet the needs of local demand, and provide a surplus of gas that can be exported to achieve economic returns that contribute to the domestic product, provide job opportunities, and improve the income level of youth, in addition to in addition to Egypt becoming its political, strategic and international weight and its entry into the club of LNG producers and exporters at the global level. Assfour, H.M, et al., (2020)

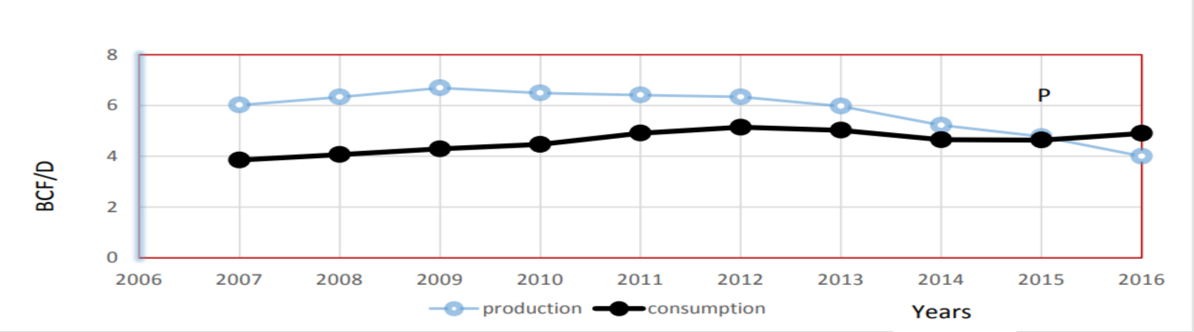

Fig. (1): production and consumption of NG in Egypt.

Resources due to the high global demand for natural gas because of its advantages, including the decrease in carbon dioxide emissions resulting from its combustion compared to other fossil fuels, especially coal and oil, this caused investments in the natural gas market to be huge and require large capital due to the gaseous nature of the fuel. There are various ways to transport natural gas including through pipelines, if the distance between the production fields to the consumption areas is short and does not pass through natural obstacles, including the rugged terrain that prevents the extension of pipelines. The liquefaction stations, where the volume of gas is reduced by 600 times, which makes storing and transporting large quantities of gas easier at a temperature of -162 degrees Celsius, whether in tanks of LNG carriers or inside tanks of land trucks between countries with common land borders. Bittante, et al., (2018)

Natural gas is found in many geographical spots worldwide, whether in America, Asia, Africa, and the Middle East. The world's natural gas reserves are estimated at about 6923 trillion cubic feet, and Egypt ranked 16th in the world in gas reserves in 2017, with reserves estimated at about 77 trillion cubic feet. Especially after the discovery of the Zohr field in the Mediterranean Sea, i.e. about 1% of the world's natural gas reserves. These reserves cover about 37.9% of Egypt's annual consumption of gas. According to the reports of the Ministry of Petroleum and Mineral Resources, Egypt's discovered gas reserves will continue for the next 38 years. Figure 2 shows Egypt's production, consumption, and export rates of liquefied natural gas, as Egypt's exports of liquefied natural gas grew to 4.8 billion cubic meters in 2019 to many Asian and European markets from the liquefaction stations in the cities of Edku and Damietta, which are located on the Mediterranean coast the Edku plant exported about 50 shipments of liquefied natural gas to many Asian and European markets in 2019, compared to 20 shipments in 2018. Egypt plans to make major expansions in logistical activities within it, such as liquefaction, storage, technical and logistical support with the insurer, fuel, and all the necessary requirements for the rigs used in gas exploration operations within the framework of Egypt's plan to become a regional center and a focal point in the global natural gas supply chain, with Egypt's keenness to implement standards Safety, safety and environmental sustainability in all the aforementioned logistical activities and raising the efficiency of their performance along the supply chain**.**Worldometers**, (**2021)

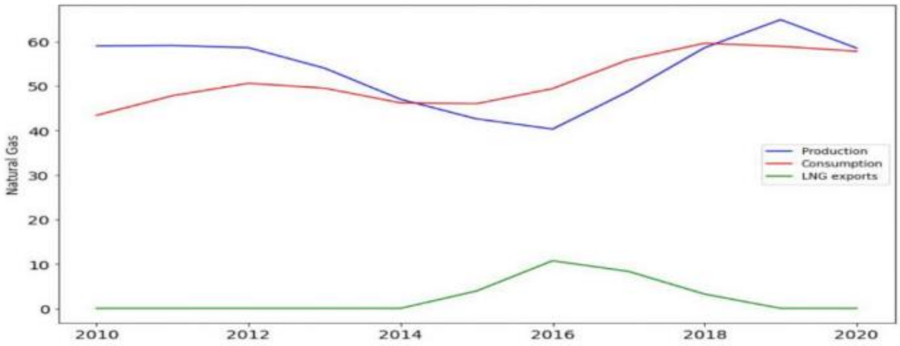

Fig.2. show the production, consumption and LNG exports in Egypt
Source: Data source: BP, 2021

1.1. RESEARCH AIMS AND OBJECTIVES

Research aim:

Studying the LNG supply chain in Egypt and the relevant logistical activities, including exploration, extraction, handling, storage, transportation and distribution from sources of production to places of consumption to achieve large economic returns especially after the discovery of many natural gas fields the most famous of which is the Zohr field.

Research objectives:

1. Designing, simulating, analysing and optimizing operations in the natural gas supply chain with the aim of improving the performance of the current LNG supply chain in the LNG terminals in Edku and Damietta, in addition to planning storage, transportation and distribution operations along the LNG supply chain in the liquefaction stations in the cities of Edku and Damietta To raise the efficiency of performing logistical activities in the LNG supply chain, and thus achieve significant economic savings.
2. Facing the dual global challenge of producing more energy while reducing waste and emissions to achieve the goals of sustainable development, in addition to the impact of the Russian-Ukrainian war on the supply of natural gas globally
3. Implement effective strategies for optimal planning of LNG storage and sales operations, taking into account global supply and demand to increase revenues

4. Discussing the foundations for developing the necessary infrastructure for the natural gas liquefaction stations in the cities of Edku and Damietta, and raising the efficiency of the supporting logistics services therein.

1.2. LITEREATURE REVIEW:

Due to the decrease in greenhouse gases resulting from the combustion of natural gas, this led to an increase in global demand for natural gas, and this resulted in saving about 24% of global energy reserves. Natural gas is transported by extending pipelines between supplying countries to consumption countries after the gas liquefaction process the pipeline passes either on land borders within the same country or between several countries. The pipeline may also cross the borders of more than one country below sea level, as is the case in Nord Stream one and two pipelines. Najibullah Khan et al., 2016, Arrhenius et al.,**(** 2018**)**

The International Energy Agency has recently predicted future scenarios related to the fact that the demand for natural gas will witness significant growth among fossil fuels because of its advantages, including low carbon dioxide emissions resulting from combustion. The International Energy Agency also predicted a growth in global energy demand, especially gas, by 37%. By the year 2040, therefore, fossil fuels will constitute 55% of the sources of burning shot globally. It is also expected that the demand for natural gas will rise to about 5.4 trillion cubic meters in 2040, in order for it to become the second largest source of energy supplies globally after oil. Bittante, et al., (2018)

As a result of the world's tendency to pay attention to liquefied natural gas as an energy source that is less polluting to the environment and has high commercial and economic returns, there has become a necessary need for exploration, extraction, storage and transportation of liquefied natural gas and organizing its trade according to market mechanisms, supply and demand to achieve a balance between production, consumption and sale, especially in light of political developments In the recent period regarding the Russian-Ukrainian war and the consequent change in Europe's dependence on Russia as a source for the supply of liquefied natural gas, which caused the world's attention to be directed to alternative sources of supply in the Middle East, including Qatar, Egypt, Saudi Arabia, Iran and others. Sangaiah, et al., (2019)

The global LNG supply chain is governed by several factors in order to raise its efficiency and reduce the cost of performing logistical activities along the chain the most important of which is the quality of gas, the cost of production, liquefaction, storage and transportation of gas, flexibility and speed of response by supply sources, and reducing the time required for delivery from the place of production to the gas consumption market. One of the most important logistical activities in the LNG supply chain is the transportation activity, whether by using pipelines or by using LNG carriers, where we find that the transportation of natural gas using pipelines is limited to a distance not exceeding 2000 km from the country of production to the country of consumption, however, transporting gas in a liquid state using ships can redirect gas shipments to separate regions around the world, and thus quickly respond to regional and international changes in supply and demand Gas is transported in liquefied natural gas tankers in various countries that own natural gas liquefaction stations. Strantzali, et al., (2019)

The latest economic reports indicated that the global liquefaction capacity reached approximately 393 million tons per year (MMTA) in November 2019, and it is expected that the liquefaction capacity will reach about 843 million tons per year in the coming years (IGU 2019), as Qatar announced that it is the largest exporter of gas. Liquefied natural gas in the world has announced an increase in its production by more than 60% during the next five years (John, 2019) to meet the demand for natural gas and implement the sales contracts it has signed with many countries. Many environmental organizations have indicated that this global expansion in gas production Liquefied natural gas causes many growing environmental concerns. Therefore, it is necessary to find opportunities for effective operation and rationalization of global consumption to reduce environmental emissions mitigate global warming and achieve sustainable development**.** Katebah, et al., (2020**)**

This paragraph displays, as shown in figures 3 and 4, the history of the development of liquefied natural gas production, passing through several generations, starting from 1990 to 2019, in addition to the most important areas of liquefied natural gas production in the world, where the produced quantity of liquefied natural gas increased from 52 million tons a year 1990 to about 419 million tons by the end of 2019. The second figure also shows the most important countries producing liquefied natural gas globally, namely Algeria, Australia, the United States of America, the United Arab Emirates, Indonesia, Malaysia and Brunei, in addition to Qatar, which entered the club of liquefied natural gas producers in 2000, reaching Nigeria and the Sultanate of Oman In addition to Egypt, which entered the club of liquefied natural gas producers in 2005, Norway in 2008, and Russia in 2009, which discovered many liquefied natural gas fields in the Arctic, which caused an increase in Russia's exports of liquefied natural gas to Europe, specifically Germany, through the well-known natural gas supply lines. In the name of Nord Stream One and Two, all of this led to an increase in the world's production of liquefied natural gas to about 264 million tons per year end of 2019. Merkulov et al., (2020)

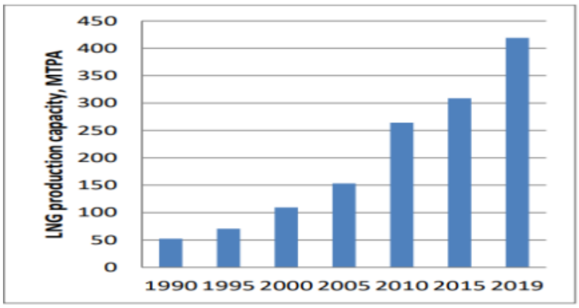

Figure 3.Dynamics of world LNG production Capacities, MTPA

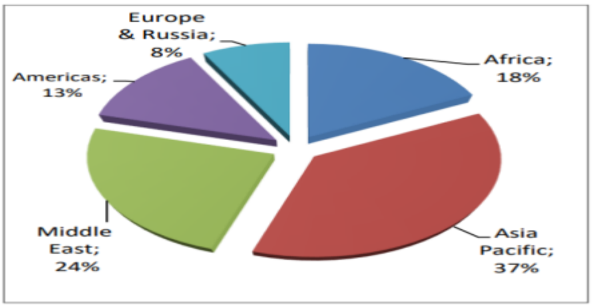

figure 4.shares of regions in the global production capacity of LNG in 2019

Prior to 2018, Egypt was importing a large percentage of its natural gas needs, due to the growth of domestic demand and the increase in gas consumption in various fields, with the annual decrease in natural gas production. This continued until 2018, when many natural gas fields were discovered, such as Zohr, Noor and Atoll. And others, which encouraged Egypt to aspire to be a regional source for the production, liquefaction and export of natural gas, due to what Egypt possesses of a distinguished strategic and geographical location, as it connects three continents, namely Asia, Africa and Europe, and what Egypt also possesses from sea outlets on the White and Red sea its efficiency and conversion into smart ports to raise its productivity and competitiveness regionally and internationally, in addition to Egypt's containment of the most important international waterway, the Suez Canal, in which about 12% of the world's trade passes. All this helps Egypt to be a regional source of liquefied natural gas. Abbas, N.S, et al., (2020)

Figure5. Cheniere Supplier-Specific Supply Chain

The figure5 shows the life cycle of liquefied natural gas and supply chains in one of the companies operating in the natural gas production sector, where the natural gas supply chain starts from the production well until the re-conversion of gas into gas at the port of final destination. Greenhouse gas emissions along this supply chain are estimated at about 30% to 43%. The drawing shows a group of logistical activities that take place across the supply chain, starting from production from the well using drilling rigs, then purification, treatment, storage, transportation to liquefaction stations, then sea transport across oceans in LNG ships, then re-conversion of liquid gas into gas in a port The final destination is then the use of gas in several areas, including electricity generation, industry, means of transport, heating, etc. Companies working in the field of gas are trying to link all elements of the supply chain together and apply environmental sustainability standards along the life cycle of natural gas and along the supply chain, and reduce emissions as much as possible and raise safety and security rates. Especially in the activities of transporting and storing gas with the aim of ensuring that there is no leakage or explosion of gas and the resulting marine environmental pollution During the transportation process in the oceans, in addition to human and material losses, all this is done with the aim of preserving the environment and achieving sustainable development. Roman-White, et al., (2021)

The increase in global energy demand in recent decades has caused a significant increase in carbon emissions, causing climate changes and raising the global temperature, which encouraged the world to promote the use of natural gas as an alternative to fossil fuels such as coal and petroleum due to the low carbon dioxide emissions resulting from its combustion, especially in light of The world moved towards protecting the environment through the use of clean energy sources, which made natural gas a major contribution to the global energy sector, as the demand for natural gas reached 24.2% in 2019. The liberalization of the energy market, climate change and the challenges of the global environment also had a major role in the search for energy sources. Esily, et al., (2022)

2. International experiences in the liquefaction of natural gas in specialized liquefaction stations.

Building liquefied natural gas liquefaction stations requires a very large capital amounting to a few billion dollars. A group of countries in the Middle East and the world have liquefied natural gas liquefaction stations, including Egypt, Libya, Oman, Qatar, the Emirates, globally, Norway, Greece, Russia and other countries in the world.

3. GAP ANALYSIS

The decrease in research papers that contributed to analysing the current situation of the global natural gas markets from the perspective of logistics and logistics services along the supply chains of liquefied natural gas, by focusing on natural gas importers in the world as target markets that Egypt will target in the coming period, whether it is European or Asian markets, and specifying paths Optimum capacity and increased ability to predict regional and global demand for lliquefied natural gas, as well as measuring the impact of recent events such as the Russian-Ukrainian war on the global LNG supply chain, and presenting the changes that occurred in the elements of the supply chain, such as changing sources of supply, transportation and storage methods, and changing gas distribution networks and centers as well, especially after Russia stopped exporting LNG to Europe and stopped Pipelines Nord Stream 1 and 2**.**

4. CONTRIBUTION

The study's contribution appears in examining, analyzing and studying a chain of supply for liquefied natural gas in Egypt through interest in raising the efficiency of the performance of logistical, operational, technical and tactical activities along the chain, with a focus on the maritime transport operations of liquefied natural gas from the gas producing countries to the countries consuming the gas.

The study also seeks to raise the efficiency of liquefied natural gas storage activities in Edku and Damietta cities in specialized warehouses that apply environmental safety standards.

The study also seeks to develop effective plans for natural gas distribution operations and measure the impact of the Russian -Ukrainian war on global gas supply sources. All of this aims to design the supply chain structure that reduces the costs of performing logistical activities and helps support decision -making processes with regard to the storage of gas that has been produced or its distribution in order to achieve a balance between production (supply) and demand, taking into account the needs of local consumption in Egypt.

5. RESEACH PROBLEM

The high cost of performing logistical activities along the LNG supply chain in the study area, and at the top of these activities are handling, transportation, liquefaction and storage due to the weakness of the existing infrastructure, whether liquefaction stations, storage tanks, or methods of transporting LNG from the source to consumers, whether by pipelines or natural gas ships liquefied or land trucks, which makes these logistical activities require huge financial investments that are not available, which weakens Egypt's competitiveness among the countries exporting liquefied natural gas regionally and internationally.

6. RESEACH AREA

According to the reports of the Egyptian Ministry of Petroleum and Mineral Resources, Egypt produced about 53 million tons of natural gas in 2021, an increase of about 17.2% compared to 2020, and Egypt's gas exports reached about one million tons in 2021. It also owns two natural gas liquefaction stations in the cities of Etko and Damietta. . Each of them has a distinct strategic location on the Mediterranean coast to facilitate the export of liquefied gas to Europe and the world, and the cost of each station is a few billion dollars, which helps Egypt to become a regional center for liquefaction and trading of natural gas. The production capacity of the liquefaction plant in the city of Edku is about 7.2 million tons annually, and it contains two gas storage warehouses, the capacity of each warehouse is 140,000 cubic meters, and the station is attached to a sea port to receive giant natural gas carriers. The cost of the station is about two billion dollars. The production capacity of the Damietta plant is about 4.8 million tons annually, and the liquefaction plant in Damietta accommodates about 750 million cubic feet per day. The investment cost of the Damietta plant is about $1.3 billion. Egypt is also considered a central point in the gas supply chain of its production. Regions to consuming regions, as liquefied gas is exported to about 20 countries around the world, including Japan, France, Pakistan, India, Greece, Belgium, South Korea, Panama, the Emirates and others. Egypt was able to achieve self-sufficiency in natural gas in 2018 thanks to what was discovered in the Mediterranean gas fields such as the Zohr and Nour fields and other fields. 4 billion cubic meters, and thus Egypt ranks 14th globally, fifth regionally, and second in Africa in natural gas production in 2021, according to what was announced by the International Energy Agency. Egypt ranks second in the world in terms of contributing to the growth of LNG exports worldwide.

7. RESEARCH METHODOLGY AND ANALYSIS

The research paper relied on a methodology based on a review that highlights the strengths on which Egypt is based in its aspirations to be a regional center for the production, liquefaction and export Egypt for its goal to be a regional gas center in North Africa in addition to reviewing the most important gas production markets in Asia and Africa and the most important gas consumption markets in Europe and America**.**

- **Strength points**

1. What distinguishes Egypt and makes it qualified to be a regional source for the production, liquefaction and export of natural gas is its distinguished geographical location, as it connects three continents, namely Africa, Asia and Europe, and Egypt is considered a gateway to all African countries
2. The sea ports that Egypt owns, Egypt has started to raise their efficiency, develop them, and turn them into smart, controlled and green ports that apply environmental sustainability standards.
3. Egypt contains the most important international waterway through which about 12% of the world's trade passes, which is the Suez Canal and the green hydrogen projects that are taking place in the economic zone of the Suez Canal, in addition to that Egypt

plans to establish some natural gas liquefaction stations discovered in the Red Sea in the economic zone to the Suez Canal.

- **Weak points**

1. Gas exploration projects require a long time and huge financial investments that may not be available to Egypt at the present time.
2. LNG production areas are exposed to geopolitical risks due to the political instability of some producing countries and the emergence of civil or internal wars, or perhaps wars between LNG producing countries and their neighbours, as is the case in the Russian-Ukrainian war, which caused a disruption in global LNG supplies.
3. LNG exports and its extraction, production, transportation, liquefaction and storage operations are greatly affected by fluctuations in the global oil production market, and are also affected by stages or periods of decline in energy consumption globally, as happened during the Corona virus period in 2020, which caused many countries to stop production, which caused a significant decrease in energy consumption. The profitability of LNG production projects globally.
4. The intensity of competition between gas producers, especially in the regions of Asia and the Pacific, where these regions are considered pioneers in the production and export of liquefied natural gas, and among these countries are Australia, Malaysia, Indonesia, Japan, China and Qatar, because these countries have high capabilities in infrastructure along the LNG supply chain and the availability of huge funds have necessary.

- **Opportunities**

1. The Russian-Ukrainian war and the consequent suspension of natural gas supplies from Russia to Europe within the pipelines Nord Stream 1 and 2, which encourages Egypt to be a regional center for importing gas from Russia, then liquefying it in the Edku and Damietta stations, and then re-exporting it again to Europe
2. Egypt's endeavours to discover natural gas in countries that have large reserves of gas, such as Libya, which can be extracted from Libya and then transported to be liquefied at the liquefaction stations in Etko and Damietta, and then exported to southern European countries using the pipeline to be established that connects Egypt with Cyprus and Greece under the depth of the waters of the Mediterranean Sea.
3. Egypt's membership in the Eastern Mediterranean Gas Forum enables it to play a pivotal role in trading natural gas trade in the eastern Mediterranean region as a central point in the global natural gas supply chain linking the three major continents of the world Asia, Africa and Europe, in addition to achieving cooperation between member states and optimal utilization of the infrastructure of each country to achieve maximum benefit from the natural gas wealth in the eastern Mediterranean region.

4. Egypt's membership in an Arab cooperation project that includes Iraq, Jordan and Egypt and is called the New Levant, with the aim of linking these gas-producing countries with a pipeline to transport gas from them as a production area to Egypt as a liquefaction area in the Atco and Damietta stations, and then export the liquefied gas to Europe, whether through pipelines or LNG vessels.

- **Threats**

1. The emergence of green hydrogen as a source of energy generation, as it has become a competitor to natural gas because of its advantages, including that it is more environmentally sustainable than natural gas and does not emit any exhaust polluting the environment.
2. The emergence of shale gas in the United States of America caused a major shift in supply lines, import and export of natural gas worldwide, and as a result of the increased production of shale gas in the United States, this caused a decline in natural gas prices globally.
3. A group of the largest natural gas producing countries, Russia and China, have established pipelines linking their natural gas production areas with gas consumption areas in Europe, including Nord Stream pipelines 1 and 2.

8. CONCLUSION AND RECOMMENDATIONS

The study presented the most important logistics activities along the LNG supply chain. Demonstrate the foundations of sustainability that must be applied in all logistics activities along the chain and supporting logistics along the LNG supply chain. The study showed that the global LNG supply chain is subject to many factors in order to raise its efficiency and reduce the cost of performing logistical activities along the chain, the most important of which are the quality of gas and the cost of production, filtering, storing and transporting gas, flexibility and speed of response from supply sources, and reducing the time required for delivery from one place to another Production to the gas consumption market. The study also referred to the environmental importance of using natural liquefied gas as a fuel instead of oil and coal. The study also showed the impact of the Russian-Ukrainian war on the fields of natural gas supply at the global level and its impact on supply and demand for LNG globally. The paper presents several recommendations to show the foundations for the sustainability of liquefied natural gas in Egypt and the most important services and logistical activities supporting it.

1. Increasing production capacity by discovering more gas fields by increasing gas exploration operations in order to achieve tangible economic returns and trying to achieve

a measure of balance between demand for gas and supply and providing the necessary gas needs for local consumption.

2. Egypt's entry into the field of building liquefied natural gas carriers to cope with the increase in the volume of gas production and the increase in global demand for gas.
3. The use of floating liquefied natural gas units that are installed on marine barges and that have the ability to withdraw and liquefy gas directly in the sea from the fields and store it directly in ships.
4. Increasing the number and capacity of liquefied natural gas receiving stations, paying attention to improving the efficiency of the infrastructure inside them, providing the necessary tanks for storage, and paying attention to raising the safety rates in the stations to ensure that no dangers occur and reduce damages to the maximum extent possible.
5. Improving the design of the structure of the LNG supply chain, identifying the factors affecting it, identifying the most important risks facing the activities of the LNG supply chain, and trying to address these risks and limit their negative effects**.**
6. Facilitating the construction of the planned project, which is a pipeline between Egypt, Greece and Cyprus, so that Egypt will be a regional center in North Africa to liquefy gas and export it to southern European countries, which is what Egypt aims to achieve, especially after the economic sanctions imposed by the United States on Russia to prevent it from exporting gas from it directly to Europe, especially after the suspension of Nord Stream lines one and two, which are used to export natural gas from Russia to Europe, specifically to Germany, which relies mainly on liquefied natural gas in industry, heating, electricity generation, nuclear power stations, and others.
7. Achieving the maximum benefit by increasing investment in gas exploration projects in the coming years in Lebanon, Jordan and Iraq and linking them to Egypt, as is the case in the new Levant project that connects Iraq, Jordan and Egypt with a pipeline to transport natural gas**.**
8. Exporting the gas produced from the Egyptian fields Noor and Zohr using the planned pipelines or LNG ships to Cyprus and Greece as receiving points to supply consumption markets in Europe**.**
9. Egypt playing the role of the central point in the natural gas supply chain in Africa and the Middle East by receiving natural gas from other countries such as Qatar, Iraq, Jordan, Lebanon and Israel, then liquefying it and exporting it to gas consumption markets such as Europe and America**.**
10. Rationalizing the domestic consumption of natural gas in Egypt, using alternative energy sources such as nuclear energy, solar energy, wind energy and electricity instead of gas to provide the largest possible amount of gas produced from the Egyptian fields to export it and provide hard currency.
11. The speedy completion of international arbitration cases related to the Damietta station so that the station can resume its activities again, as the cost of establishing a new station currently may reach 7 billion dollars, and there are no gas liquefaction stations in any

eastern Mediterranean country, and this is considered a competitive advantage for Egypt Helping it to become a regional center for natural gas liquefaction**.**

12. Because of the discovery of shale gas in America, natural gas prices decreased globally, and therefore Egypt must search for alternative markets to export the gas produced from the Egyptian fields while providing more facilities, including long-term gas sales contracts and entering into partnerships to produce and export gas with neighbouring countries such as Libya.
13. Providing appropriate government support and gas exploration companies and providing technical and logistical support for these projects**.**
14. Paying attention to the infrastructure in the regions of Edku and Damietta with regard to the areas of gas extraction, storage and logistical supply in terms of insurance, fuel and all needs and services in the fields of production, liquefaction and storage of gas**.**
15. Allowing the private sector in the field of gas exploration and taking care of industries based on gas and petrochemicals and exporting them to Arab and African markets to save hard currency.
16. The government must work to facilitate the issuance of gas exploration licenses and to pay all arrears to Egyptian and international gas companies.
17. Achieve integration and linkage between all elements of the LNG supply chain, starting from producers, then suppliers, then manufacturers, all the way to final consumers.

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NUTRITIONAL AND TOXICOLOGICAL IMPORTANCE OF NICKEL, COPPER AND ZINC ELEMENTS IN *SPIRULINA PLATENSIS*

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ABSTRACT

The presence of heavy metal ions in water is hazardous to one's health and the environment. Algae are frequently exposed to heavy metal pollution as a result of industrial waste dumping into water environments. *Spirulina platensis*, a significant kind of algae utilized commercially (especially for fish feeding) as a good source of protein, amino acids, minerals, vital unsaturated fatty acids, and a number of vitamins, was selected for this study because of its high nutritional value. This study examined how *S. platensis* responded to five different concentrations of the three heavy metals (nickel, copper, and zinc) in terms of its growth, fatty acid IR spectra, content, and total soluble protein profile. The remaining four doses (two higher and two lower) for each element were selected to evaluate the findings of 5 different concentrations of the three heavy metals because the EC50 for those three was almost at 2.0 mg/l. Compared to zinc and nickel, copper demonstrated a greater growth inhibitory impact as determined by optical density. Cu^{2+} was more noticeable than Zn^{2+} and Ni^{2+} when compared to control cells in the IR spectra, which showed the creation of new molecules and the lack of other compounds. Total fatty acids decreased under stress at all concentrations examined, while saturated fatty acids outnumbered unsaturated fatty acids. Cu^{2+} stress resulted in a more marked destructive effect of the heavy metal ions the protein profile than Zn^{2+} or Ni^{2+} stress.

KEYWORDS: Heavy metals; Environmental Pollution; *Spirulina platensis;* Fatty acids; Infra Red; Protein profile.

INTRODUCTION

The industrial revolution contributed to heavy metal pollution. Both the ecology of the environment and the life quality are impacted by pollution. Heavy metals play a vital role in many sectors, and they release a lot of pollution into the environment. Egypt has five lakes in the Mediterranean (Burullus, Mariut, Edku, Manzala, and Bardawil). They play a crucial role in supplying a priceless natural resource for the growth of fish. For a very long time, heavy metal contamination in the aquatic environment has been recognised as posing a serious hazard to aquatic life, especially fish. These lakes have the following degrees of pollution: Manzalah in the first order followed by Edku , Burollus , Bardawil and Mariut (**Saad, 2003**).

Being the base of the aquatic food web and the principal producers, phytoplankton is a varied collection of microbes that is essential for preserving species diversity, (**Hanan *et al.*, 2015**). The potential of microalgae bioenergy systems in terms of resources, energy, biofuel generation, and high-value products has all been carefully examined. *Spirulina platensis* stands out among economically significant microalgae for its high protein content, pigment, and fatty acid, making it appropriate for application in animal and human feeding, (**Nethravathy *et al.*, 2019**). The two species that are utilised commercially the most frequently are *Spirulina platensis* and *Chlorella vulgaris*. According to current estimates, the annual dry matter output of *chlorella* and *spirulina* in the world is 6600 and 12,000 tons, respectively (**Garcia *et al*., 2017**). For *S. platensis*, values for lipid content range from 9 to 17 % DW, depending on the culture conditions in addition to protein., **(Piorreck *et al*., 1984**). Due to its great nutritional content, *spirulina* has become popular as a promising and useful feed additive. Furthermore, its rich phytochemicals have considerable anti-inflammatory and antioxidant properties, (**Abdel-Latif *et al*., 2022).** Production of microalgae aims for the highest levels of biomass production and quality while minimizing nutrient shortages and other unfavourable growing situations. A total nitrogen measurement overestimates the genuine protein level since protein includes nitrogen along with other nitrogenous constituents such as fatty acids, amines, and cell wall material, (**Muys *et al*., 2019**). It is well known that microalgae are good heavy metal bio-accumulators, (**Arunakumara and Xuecheng, 2008**; **Kaamoush *et al*., (2022**). While certain metals, like As, Hg, Cd, Pb, and Ni, are poisonous, Zn, Cu, and Cr are necessary for human nutrition but can be hazardous if ingested in excess. Other metals, including Hg, As, Pb, Cd,and Ni, are toxic. The toxicity of heavy metals to individuals and the environment is a global issue. An effective bio-accumulator of a variety of heavy metals is *spirulina*, (**Sanjib, 2020**). Nowadays, *Spirulina platensis* is frequently used to combat malnutrition, especially in young infants. Due to its high levels of protein, vitamins, minerals, healthy fatty acids, and other restorative phytonutrients like different active plant colours, these blue-green cyanobacteria microalgae are cultivated in temperate seas all over the world and are regarded as a functional food. *Spirulina* was recognised by the World Association for Applied Microbiology as a possible food source in 1967, (**Lupatini *et al*., 2017**). *Spirulina platensis* has a high nutritional value because to its abundance of amino acids and considerable amounts of -linoleic acid and other unsaturated fatty acids. Calcium, potassium,iron, magnesium, manganese, phosphorus, selenium, and zinc are among the minerals that may be found in it. *Spirulina* contains a number of vitamins, including E, B1, B2, and B12, (**Pyne *et al*., 2017).**

Over the last ten years, the nutritive benefits of *spirulina* in aquaculture feeds has been carefully examined as a fishmeal substitute or as a functional feed supplement to enhance fish growth and performance. Due to its high protein content (up to 70%), enormous amount of vital fatty acids, antioxidant pigments (phycobiliproteins and beta carotene), and polysaccharides, commercial *spirulina* production has grown in popularity for use in medical products, nutritional omega-3s for humans and animals, and cosmetics. *Spirulina* can replace animal-derived proteins in aquafeed for aquaculture, (**Ragaza *et al*., 2020).** These fatty acids, which have significant structural, chemical, and functional functions in human metabolic pathways, can be produced by *spirulina*. Along with serving as a source of energy, fatty acids, especially omega-3 and omega-6, have emerged as a common reference point for conditions including cardiovascular, neurological, and endocrinologic ailments, (**Zheng *et al*., 2012**).

MATERIALS AND METHODS

I-Growth measurement:

Spirulina platensis was cultivated in (**Zarrouk, 1966**). Growth of *Spirulina platensis* can be best determined by optical density (degree of turbidity) measurements. Using a Perkin Elmer (Lambada 1) ultra violet spectroscopy with a 560 nm wave length, this approach measures the percentage of light transmittance (T) that has changed in comparison to control tubes that have not been infected and are set at 100% T. The following equation was used to compute the optical density(**Robert, 1979**):

Optical density (O.D.) = log I_0/I

Where: I= the transmittance of sample. $I_{O=}$ the transmittance of blank adjusted to read 100%.

II-Preparation of different heavy metal concentrations

$NiCl_2$, $CuSO_4.5H_2O$, and $ZnCl_2$ were purchased from Algmhoria Co. in Alexandria, Egypt. The three heavy metals nickel, copper, and zinc were chosen for this inquiry due to their ubiquity in industrial waste water and their negative impact on the ecosystem. Stock solutions for the chosen heavy metals were prepared by dissolving their salts in double-distilled water and sterilising the mixture using 0.2-m nitrocellulose membranes. By dilution with doubly distilled water, the various concentrations of selected heavy metals employed in the metal bioassays were created. The three heavy metals' EC50 was discovered to be around 2.0 mg/l. We selected four concentrations—two higher and two lower—for each of the three heavy metals in order to compare the outcomes of five distinct concentrations.

III- IR Measurements of cells tested

The density of cell suspensions required to produce spectra with a good signal was determined in preliminary trials. According to **Kansiz *et al*., (1999)** a known volume of algal culture pellets were treated with Lugol's iodine solution. The stage of the infrared microscope was set up with the dried cells so that spectral data could be collected for IR analysis. The spectra were collected using a ratio recording infrared spectrophotometer, the Perkin Elmer 1430. The absorbance spectra were collected between 4000 and 500 cm-1 and averaged using 10 scans.

IV-Measurements of total lipid extraction

The examined alga Spirulina's total lipid content was extracted, as according **Bligh and Dyer (1959).** By adding 50 ml of a chloroform and methanol mixture (2: 1 v/v) to 50 ml of the algal cells in a separate funnel, the total lipids were completely extracted. After two layers formed, the aqueous layer containing the remaining cells was discarded, and the other layer containing the lipid extracts was washed with a 0.4% $MgCI_2$ solution (100 ml) before being repeatedly washed with distilled water (100 ml) For acidification, this extract was then combined with 1.5 N HCl. In order to separate fatty acids from oils, acidified extract was added to a separating funnel with 50 ml of 1n-hexan and 50 ml of newly made sodium carbonate. In order to re-acidify this mixture, 2 ml of 1.5 N HCl was added. A rotary evaporator was used to evaporate the filtrate after the hexane layer, which contained the fatty acids, was separated from the water layer and dried over anhydrous Na_2SO_4 to remove water droplets.

The resulting residue is a representation of all lipids. The vial was cooked in an oven at 90°C for 90 minutes before being submerged in a stream of nitrogen. The methyl ester of each vial was extracted three times using 5 ml of petroleum ether after the vial was cooled to room temperature and 10 ml of distilled water was added. Before detecting the fatty acid methyl esters, the three petroleum ether extracts were mixed and reduced in volume using a stream of nitrogen. On a gas chromatography device, all studies for the identification of fatty acids fractions were carried out.

V-Measurements of protein profile

By boiling dialysis tubing (cut into small lengths of about 15 cm each) for 15 minutes in a solution of 1% sodium bicarbonate and 10-3 M Na2EDTA, protein profiles were calculated. After centrifuging 10 ml of culture, the freshly frozen cell pellet of algal material was obtained. It was then homogenised by grinding it in a mortar with quartz sand and a small amount of 0.5 M Tris-HCl buffer (PH 7.2). The solution was spun at 500 rpm for 10 minutes to concentrate the supernatant, which was then concentrated over a bed of sucrose in pre-activated dialysis tubing.

RESULT AND DISCUSSION

A- Growth:

The optical density (O.D.) of *Spirulina platensis* is an important growth parameter that is used as a risk indicator for various contaminants, particularly heavy metals. According to the results obtained after 8 days of culturing, Around 2.0 mg/L was the effective concentration (EC50) of nickel, copper, and zinc (different experiments have been done to determined effective concentration of the three examined heavy metals).

As a result, in this study five different concentrations were chosen (for each element besides control. Copper had a stronger inhibitory effect on growth than nickel and zinc at all concentrations tested. Algal growth was slowed down as copper concentration rose, while it was stimulated at the minimum concentration (1.0 mg/L). Our results are in agreement with **(Budi et al., 2020),** who found that the extraordinary growth rate of *Spirulina platensis* was reported by who noted that the treatment with the addition of 1 mg/L of heavy metal is necessary for boosting growth, but the greater the concentration of Cu provided, the lower the density of *Spirulina platensis*. We found that lower quantities of zinc and nickel enhanced development of Spirulina platensis and that they are regarded growth accelerators of *Spirulina platensis* when utilised at low concentrations. Zn^{2+} ions were more hazardous than Ni^{2+} ions. These results are consistent with those of **Meenakshi *et al.*, (2007)** who found that copper toxicity, which was greater than zinc, caused a considerable decline in growth in *Spirulina platensis* culture.

Heavy metal toxicity may be indicated by alterations in the growth environment and a decline in the development of the test microorganism. At low concentrations of zinc and copper, **Akbarnezhad *et al.*, (2019)m**'s research revealed that the optical density of *Spirulina platensis* culture gradually increased. *Spirulina platensis*, on the other hand, has a strong capacity in biosorption and bioaccumulation for heavy metal ions, making it a desirable option for environmental bioremediation, according to **Zinicovscaia *et al.*, (2021)**. They observed that it has a higher bioaccumulation capacity for Zn than Ni and Cu ions.

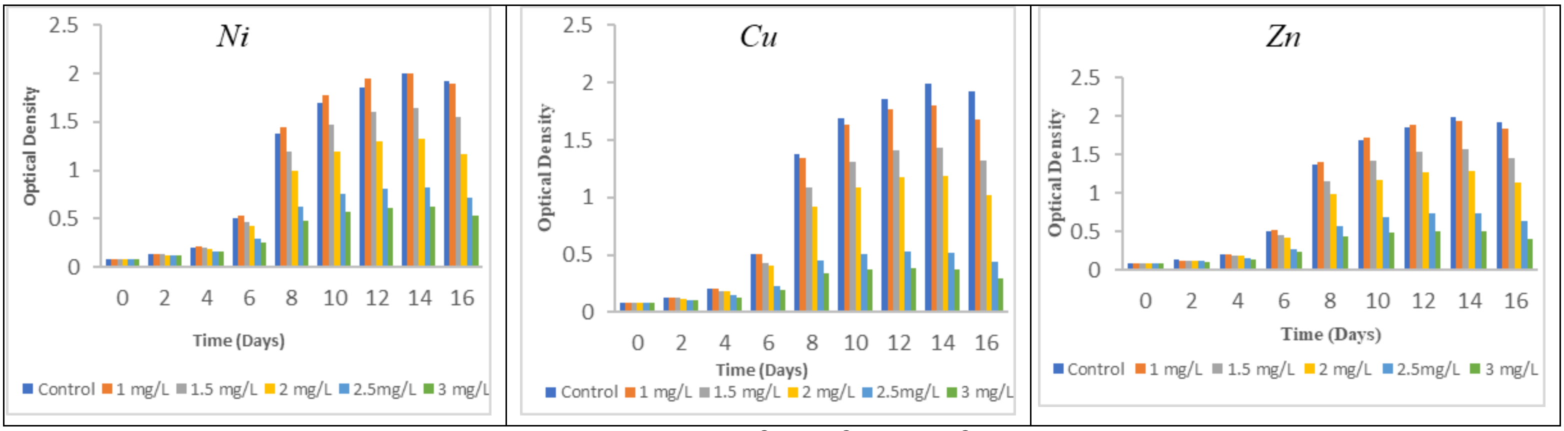

Figure 1: Effect of different concentrations of Ni^{2+}, Cu^{2+} and Zn^{2+} on growth of *Spirulina platensis* cultured for 16 days of culturing measured in optical density.

B- IR Spectra:

Infrared spectroscopy is quick and reliable, needs a small sample size, and has a straightforward sample preparation process, which are all benefits over other conventional methods of biochemical analysis **(Kansiz *et al*., 1999).** Based on research on *S. platensis* entire cells, compartments, and biomolecules in the 4000-250 Cm-1 range, infrared spectra of the complete cell contents showed band assignments. The data show that there are several spectral regions that potentially explain the chemical variations in this species (**Fig.2, 3 and 4**).

When *S. platensis* was cultivated for 8 days under the stress of various concentrations of Ni^{2+}, Cu^{2+}, and Zn^{2+} ion metals, the obtained infrared peaks of the primary cell constituents were examined. When compared to the control, it is evident that some peaks disappeared, others appeared new, and still others remained the same. The new peaks that developed when these three components were stressed could have resulted from side chain position alterations or the breakdown of some compounds with high molecular weights into those with lower molecular weights. These ideas are consistent with those obtained by **Al-Osaimi, (2010)**. Infrared spectroscopy is quick and reliable, needs a small sample size, and has a straightforward sample preparation process, which are all benefits over other conventional methods of bioassay **(Kansiz *et al*., 1999).** Based on research on S. platensis entire cells, compartments, and macromolecules in the 4000-250 Cm-1 range, infrared spectra of the complete cell contents showed band assignments.

The asymmetric and symmetric C-H of the methylene groups were present in the disappearing peaks, which disappeared at frequency 4500-4000 and 3500-3000 cm-1, respectively. The number of peaks is the same for Cu concentrations of 1.0 and 1.5 mg/l (14 peaks), but it is lessened at Cu concentrations of 2.0, 2.5, and 3.0 mg/l (13, 12 and 7 peaks, respectively). The number of gone peaks was 5, 5, 6, 8 and 7 peaks, with respective concentrations of 1.0, 1.5, 2.0, 2.5 and 3.0 mg/l. At doses of 1.0 to 2.0 mg/l, there were five new peaks that emerged, and at 2.5 mg/l, there were six new peaks. Cu concentration 3.0 mg/l produced just one peak.

Accordingly, as compared to untreated cells, new peaks in the spectra of the studied algae species S. platensis cultured at various dosages of Ni, Cu, and Zn emerged while other components vanished. The disappearance of some compounds, the protracted process of their synthesis, the movement of some side chains within a single molecule, and/or the dissociation of complex compounds into simpler ones may be the causes of these peaks. Our findings are consistent with those made by **El-Agawany and Kaamoush (2022),** they noted that the important cell components of *Dunaliella tertiolecta* procured infrared peaks demonstrated the development of new peaks and the damage of others, revealing changes in cell components brought on by the presence of different concentrations of zinc element.

The new peaks, which correspond to the amides associated with proteins as well as the function groups of other amides from lipids and fatty acids, emerged in all of the examined elements at frequencies between 2500 and 1000 cm-1 (**Williams and Feleming 1996**). When Ni^{2+}, Zn^{2+}, and Cu^{2+} were added to control and modified cultures, more peaks at frequencies between 1500 and 1000 cm-1 occurred than in any other concentration examined. These frequencies correspond to the phosphodiester backbone of nucleic acids and the amides associated with protein (**Noctor and Foyer, 1998**).

Last but not least, it can be concluded that Cu^{2+} metal ions are more hazardous than Ni^{2+} and Zn^{2+} metal ions, and the degree of stress is mostly determined by the element's type, concentration, and duration of culture. This has been proven by the findings of (**El-Sheikh *et al.*, 1999**), which showed that the type of element and its concentration affect the deleterious effects of heavy metals.

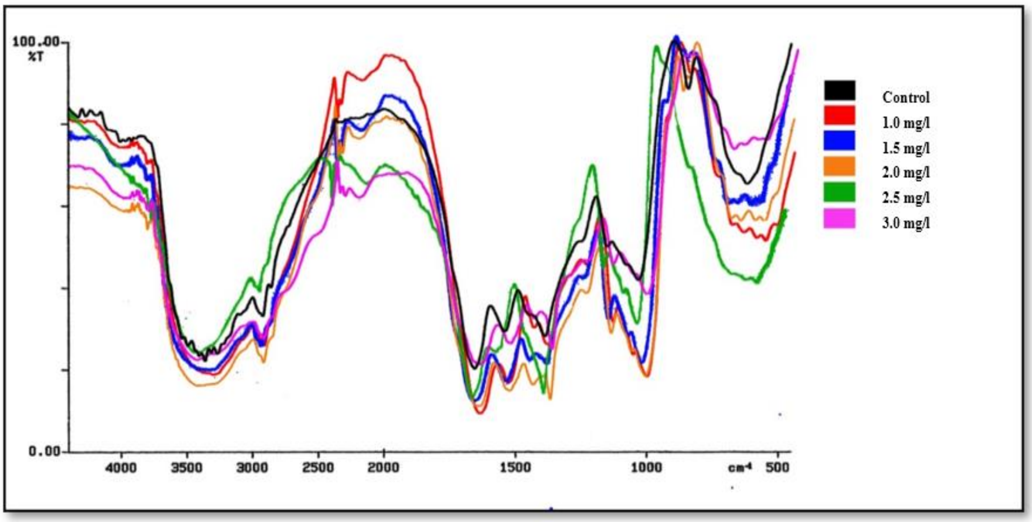

Figure 2: Infrared spectra of *Spirulina platensis* cell components grown for 8 days with various Ni^{2+} concentrations.

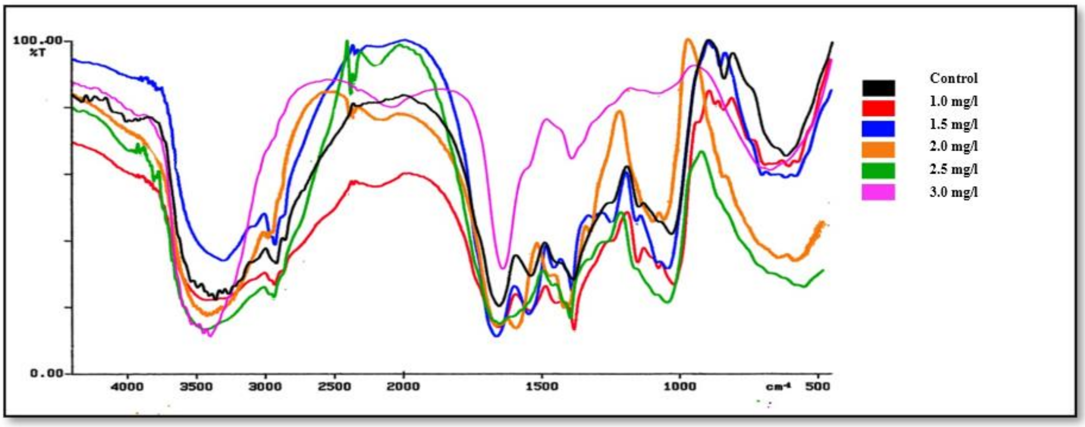

Figure 3: Infrared spectra of *Spirulina platensis* cell components grown for 8 days with various Cu^{2+} concentrations.

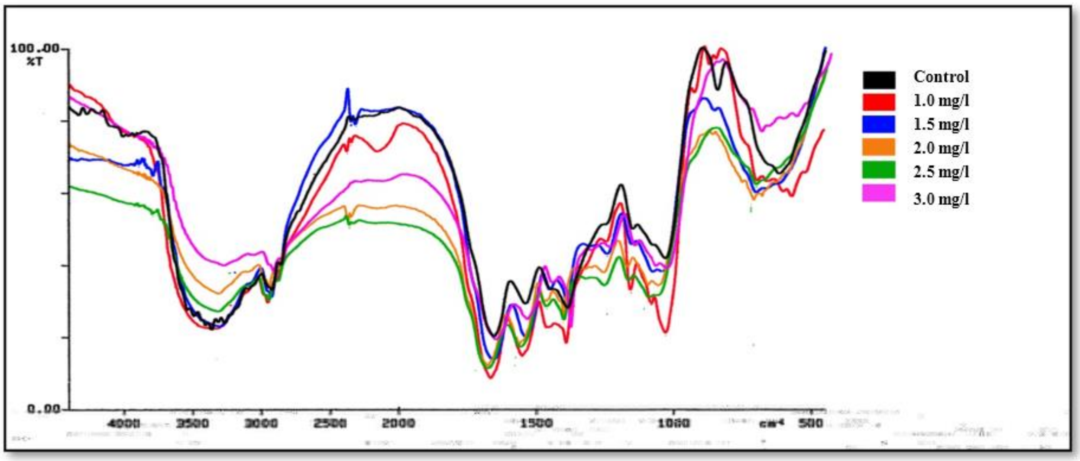

Figure 4: Infrared spectra of *Spirulina platensis* cell components grown for 8 days with various Zn^{2+} concentrations.

C- Fatty acids:

The development and survival of aquaculture are correlated with the fatty acid composition of dietary microalgae. Lipid synthesis typically varies between genera, species, and strains of microalgae, which is a well-known fact. But in healthy phytoplankton, total lipid fractions range widely, from less than 1% to more than 40% of dry weight, (**Dubinsky *et al*., 1978).** *Spirulina* contains a high concentration of highly valuable phytocompounds with distinct functional properties, such as omega-3&6, carotenoids, and phenolic acids (**Pyne *et al*., 2017**). Certain disorders, like coronary heart disease, can be prevented and treated in part by fatty acids, (**William, 2000**). Both the overall quantity of lipids and the relative concentrations of fatty acids can be impacted by environmental factors. Additionally, the lipid category and fatty acid content of microalgal cells can vary greatly depending on the stage of development, (**El-Maghrabi 2002**).

Regarding the impact of various Ni^{2+} ion concentrations (1.0, 1.5, 2.0, 2.5, and 3.0 mg/l) on the content of the 3 groups of fatty acid fractions (saturated, mono-, and poly- unsaturated fatty acids) in *S. platensis*, it is evident that Ni^{2+} ions have a weakly harmful effect on the content of fatty acids in S. platensis when compared to control. In comparison to control, the level of saturated fatty acids rose by 12.36, 10.01, 10.66, 9.02, and 18.40% at each of the tested Ni doses. Additionally, the saturated fatty acids (C20:0 and C21:0) entirely vanished at concentrations 2.0 and 2.5 mg/l $Ni^{2+.}$ However, the effects of the various Ni ion concentrations led to an increase in total saturated fatty acids.

It is clearly obvious that all three groups of fatty acids are significantly impacted, especially at high concentrations of the elements, based on the total fatty acids content of the examined alga *S. platensis* after 10 days of incubation in relation to the five concentrations of the selected elements. However, depending on the category of fatty acids, these metals had different negative impacts. Therefore, the total content of the three types of fatty acids decreased when the element's concentration was increased. It was determined that this drop was quite substantial. It was discovered that the harmful effects of Ni^{2+}, Zn^{2+}, and Cu^{2+} were concentration-dependent, meaning that the toxic effect increased as the element concentration increased. **El-Sheikh *et al.* (1999)** recorded that toxicity of the element was a concentration dependent. Cu^{2+} concentration had a higher negative impact on *Spirulina platensis* than Zn^{2+} and Ni^{2+} concentrations. The toxic effect of all fatty acid groups ranged from highly significant at low concentrations to extremely significant at high concentrations. The three tested heavy metals inhibited the synthesis of all groups of fatty acids at higher concentrations, but the degree of inhibition was more pronounced at higher concentrations, particularly in the content of polyunsaturated fatty acids. The results indicated that the toxic effect of the tested element on fatty acid content in *S. platensis* was more pronounced in the case of mono- and poly-unsaturated fatty acids than saturated fatty acids.

At the tenth day of culture, the organism normally synthesizes 27 fractions of fatty acids. **Dempester and Sommerfeld, (1998)** observed that nutrient deficits may result in an increase in cell lipid content, and as a result, older, healthier cultures of cells have fatty acid content that is higher than cells grown during the lag phase of growth. The two most dominant ones were the mono-unsaturated fatty acid C18:1 and the poly-unsaturated fatty acid C18:2. **Cohen,(1991**) reported that polyunsaturated fatty acids including lindonic acid, arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid are all abundant in microalgae. Numerous authors have indicated that linolinic acid (C18:2) fatty acid is necessary for the survival and development of a variety of young aquaculture organisms, (**El-Maghrabi, 2002**).

The overall level of saturated fatty acids decreased by 8.51% compared to control at 1.0 mg/l Cu^{2+} concentration. These findings could support previous findings about growth, when an organism showed limited growth at the same concentration compared to the control. At concentration (1.0 mg/l) of Cu^{2+}, the saturated fatty acid C6:0 jumped by 287.56% compared to the control. The findings demonstrated that mono-unsaturated fatty acids dropped at all concentrations examined, though at varying rates depending on the element's concentration. Despite the fact that total poly-unsaturated fatty acids increased in response to all of the Cu concentrations studied, C20:5 was not detected at concentrations 2.5 and 3.0 mg/l, C20:3 at control and at concentration 3.0 mg/l, C20:2 and C22:6 were not detected at concentrations 1.5, 2.5, and 3.0 mg/l. C22:2 was detected at concentrations of 1.0 and 2.0 mg/l but not at control, 1.5, 2.5, or 3.0 mg/l. However, the total fatty acid concentration decreased at all concentrations tested, (**Fig. 5- 10**).

It is evident when considering the five tested concentrations of Zn^{2+} on the content of the 3 groups of fatty acids (saturated, mono-, and poly-unsaturated fatty acids) in S. platensis that the total of the 3 groups of fatty acids increased at concentrations of 1.0, and 1.5 mg/l Zn^{2+} (4.993 and 0.006% over control), whereas at concentrations 2.0, 2.5, and 3.0 mg/l Zn the total content decreased by 0.009, 0.009 and 0.005% below control, respectively. Under all of the Zn ion concentrations that were evaluated, there was a rise in the quantity of saturated fatty acids, and the percentage of the increase varied depending on the Zn^{2+} concentration. In regard to mono-unsaturated fatty acids, our findings are consistent with those of **Alam *et al.*, (2010)** and **Balaji, (2015)** who observed that By interfering with chloroplast structure and result in changes in fatty acid content, heavy metals have the ability to influence the rate of photosynthesis. In addition, (**El-Agawany and Kaamoush, 2022**) found a discovery that confirms our findings they found that overall concentration of the three fatty acid groups was decreased when zinc was increased in *Dunaliella tertiolecta* cultures, and the harmful effects of Zn^{+2} were more evident for mono- and poly-5-unsaturated fatty acids than for saturated ones. **Dempester and Sommerfeld (1998)** noted that increasing the $MgCl_2$ content in the culture medium had a discernible impact on some diatoms' ability to produce neutral lipids. The presence of divalent metal cations, particularly magnesium (Mg^{2+}), was shown to be necessary for the activity of acetyl-CoA carboxylase, an enzyme used early in the synthesis of fatty acids, according to **Roessler (1989),** The same author noted decreased acetyl-CoA activity in the presence of only manganese (Mn^{2+}) and no acetyl-CoA activity in the presence of only cobalt (Co^{2+}). Increased lipid yield was observed with increasing salt concentration, which may cause physiological stress in *Botryococcus braunii* and *Isochrysis* species (**Ben-Amotz *et al*. 1985**) and in *Chlorella* species (**Tadros 1985**). **El-Maghrabi, (2002).** Nutrient limitation was identified as one of the major factors that enhanced lipid biosynthesis. The same results were achieved in our study. Cyanobacteria, on the other hand, do not exhibit significant changes in their lipid content and fatty acid composition in response to nitrogen supply (**Becker, 2004**). Nitrogen limitation was discovered to be an effective method of increasing lipid content, primarily at the expense of protein, (**Piorreck *et al.*, 1984**).

Simonopoulos, (1991) revealed that microlagae were a good source of Omega-3 fatty acids, which are protective against chronic illnesses like cancer, diabetes, and coronary heart disease. **Chu and Dupuy, (1980)** concluded that effects on fatty acid desaturation pathways may be responsible for variations in the relative quantities of polyunsaturated fatty acids. **Xu *et al*. (1997 and 1998),** reported that a decrease in membrane fluidity and permeability may be the cause of the decline in polyunsaturated fatty acid fractions. According to **Dowidar (1983),** in stressful circumstances, saturated fatty acids predominated over unsaturated ones. Our findings also indicated the same conclusion.

Table 1: The effect of varying Ni^{2+} levels on the fatty acid fraction content (µg/ml) of *Spirulina platensis* grown for 10 days.

Fatty acids		Control	Different Ni^{2+} concentrations (mg/l)				
			1.0	1.5	2.0	2.5	3.0
Saturated fatty acids	C6:0	0.789	1.488	1.112	8.644	9.644	12.312
	C8:0	1.360	2.477	0.755	0.435	0.263	0.695
	C10:0	0.416	1.056	0.423	0.241	0.192	0.430
	C11:0	0.915	1.486	0.890	0.583	0.469	0.539
	C12:0	0.336	0.924	0.564	0.256	0.273	0.403
	C13:0	2.640	3.644	2.592	2.018	1.384	1.596
	C14:0	2.020	2.032	0.320	1.257	1.480	1.661
	C15:0	1.232	1.158	1.067	0.882	0.606	0.669
	C16:0	35.324	40.647	47.297	43.171	40.929	41.181
	C17:0	0.161	0.046	0.333	0.311	0.308	0.269
	C18:0	9.428	4.333	5.113	3.912	5.243	5.345
	C20:0	0.484	0.148	0.457	--	--	0.547
	C21:0	0.658	0.216	0.421	--	--	0.375
Total		55.763	59.657	61.346	61.71	60.791	66.022
% of increase		---	(+)6.98	(+)10.01	(+)10.66	(+)9.02	(+)18.40
Mono- unsaturated fatty acids	C14:1	6.571	14.182	1.626	9.475	10.214	10.163
	C15:1	2.115	1.786	2.115	1.831	1.601	2.578
	C16:1	2.022	3.652	4.464	4.642	4.672	2.793
	C17:1	0.394	0.131	0.354	0.222	0.216	2.449
	C18:1	16.063	2.868	6.830	4.267	7.046	5.041
	C20:1	0.253	0.435	0.397	--	--	--
	C22:1	2.372	4.072	1.937	0.487	0.400	1.422
Total		29.79	27.128	17.723	20.924	24.149	24.446
% of decrease		---	(-)8.94	(-)40.51	(-)29.76	(-)18.94	(-)17.94
	C18:3	5.941	4.090	9.610	8.723	6.704	4.305
Poly-unsaturated fatty acids	C18:2	7.785	4.870	8.327	7.276	6.307	4.155
	C20:5	0.155	0.152	0.368	0.539	0.271	0.166
	C20:3	--	0.415	0.766	0.500	0.781	0.175
	C20:2	0.275	0.824	0.726	--	0.483	--
	C22:6	0.292	1.147	0.371	0.330	0.260	0.131
	C22:2	--	1.251	0.763	--	0.255	0.600
Total		14.448	12.749	20.931	17.369	15.061	9.53
% of increase or decrease		---	(-)11.76	(+)44.87	(+)20.22	(+)4.24	(-)34.04
Grand Total content		100.001	99.533	100.000	100.003	100.001	100.091
% of increase or decrease		---	(-)0.47	(-)0.009	(+)0.002	0.000	(+)0.090

Table 2: The effect of varying Cu^{2+} levels on the fatty acid fraction content (µg/ml) of *Spirulina platensis* grown for 10 days.

Fatty acids		Control	Different Cu^{2+} concentrations (mg/l)				
			1.0	1.5	2.0	2.5	3.0
Saturated fatty acids	C6:0	0.787	3.053	4.631	0.511	1.050	1.510
	C8:0	1.361	1.061	1.079	1.849	0.276	1.877
	C10:0	0.416	0.362	0.641	0.474	0.165	0.446
	C11:0	0.915	0.944	0.918	0.698	1.118	0.771
	C12:0	0.336	0.373	0.781	0.641	0.541	0.593
	C13:0	2.642	2.459	2.727	1.921	3.674	2.864
	C14:0	2.018	1.737	2.050	1.661	2.161	1.396
	C15:0	1.234	0.243	0.222	0.881	0.238	1.021
	C16:0	35.324	31.800	38.408	40.202	39.111	39.029
	C17:0	0.161	0.266	0.377	0.337	0.273	0.548
	C18:0	9.427	6.878	7.392	7.108	6.786	5.173
	C20:0	0.484	0.762	--	0.791	0.296	--
	C21:0	0.658	1.077	0.580	0.797	0.758	0.663
Total		55.763	51.015	59.808	57.87	56.447	55.89
% of increase or decrease		---	(-)8.51	(+)7.25	(+)3.78	(+)1.23	(-)1.21
Mono- unsaturated fatty acids	C14:1	6.573	2.871	8.377	6.496	8.017	7.763
	C15:1	2.113	0.744	2.179	1.868	1.965	1.100
	C16:1	2.020	4.377	3.500	3.332	4.901	4.028
	C17:1	0.396	0.343	0.429	0.365	0. 459	2.489
	C18:1	16.063	12.787	9.629	10.060	6.107	10.710
	C20:1	0.253	0.293	--	0.297	0.439	--
	C22:1	2.372	3.244	1.181	3.353	1.665	1.519
Total		29.79	24.659	25.295	25.771	23.547	27.609
% of decrease		---	(-)17.22	(-)15.09	(-)13.49	(-)20.96	(-)7.32
	C18:3	5.941	7.735	6.646	6.461	8.682	7.887
Poly-unsaturated fatty acids	C18:2	7.785	8.682	7.805	7.297	11.053	8.611
	C20:5	0.157	0.244	0.255	0.207	--	--
	C20:3	--	0.756	0.190	0.277	0.272	--
	C20:2	0.272	0.823	--	0.647	--	--
	C22:6	0.293	0.496	--	1.042	--	--
	C22:2	--	0.072	--	0.234	--	--
Total		14.448	18.808	14.896	16.164	20.007	16.497
% of increase		---	(+)30.18	(+)3.10	(+)11.88	(+)38.48	(+)14.18
Grand Total content		100.001	94.482	99.999	99.995	100.001	99.196
% of decrease		---	(-)5.52	(-)0.002	(-)0.006	0.000	(-)0.805

Table 3: The effect of varying Zn^{2+} levels on the fatty acid fraction content (μg/ml) of *Spirulina platensis* grown for 10 days.

Fatty acids		Control	Different Zn2+ concentrations (mg/l)				
			1.0	1.5	2.0	2.5	3.0
Saturated fatty acids	C6:0	0.786	1.646	6.766	36.453	4.975	1.573
	C8:0	1.362	1.465	1.173	3.058	1.605	0.960
	C10:0	0.416	1.021	0.867	4.290	1.035	0.062
	C11:0	0.915	1.422	0.734	1.948	0.925	1.014
	C12:0	0.336	1.282	0.770	0.218	0.436	0.585
	C13:0	2.642	4.808	1.618	5.241	3.402	2.992
	C14:0	2.018	0.694	1.433	4.630	2.253	1.936
	C15:0	1.234	2.074	0.746	2.082	1.638	2.132
	C16:0	35.324	36.644	33.581	15.877	32.458	35.601
	C17:0	0.161	5.494	0.137	0.800	0.3210	0.208
	C18:0	9.427	6.325	7.629	3.153	9.935	8.406
	C20:0	0.486	1.241	3.753	0.949	0.923	0.171
	C21:0	0.656	0.981	0.417	0.311	1.601	0.534
Total		55.763	65.097	59.623	79.010	61.506	56.174
% of increase		---	(+)16.74	(+)6.92	(+)41.69	(+)10.30	(+)0.74
Mono-unsaturated fatty acids	C14:1	6.571	3.471	7.365	7.284	4.694	7.981
	C15:1	2.115	3.078	1.598	0.353	2.712	6.112
	C16:1	2.023	2.344	1.828	1.114	1.764	2.007
	C17:1	0.393	0.927	0.325	0.167	0.669	0.315
	C18:1	16.066	10.086	12.500	3.799	9.345	7.970
	C20:1	0.253	--	0.273	--	0.425	0.355
	C22:1	2.371	1.503	1.595	0.429	3.183	4.003
Total		29.79	21.409	25.484	13.146	22.792	28.743
% of decrease		---	(-)28.13	(-)14.45	(-)56.14	(-)23.49	(-)3.51
	C18:3	5.941	8.540	7.347	2.620	5.666	6.102
Poly-unsaturated fatty acids	C18:2	7.785	8.400	6.802	3.217	7.533	8.475
	C20:5	0.153	--	--	0.241	0.215	--
	C20:3	--	0.287	0.353	--	0.276	0.168
	C20:2	0.276	1.007	0.244	--	0.818	--
	C22:6	0.293	--	0.154	0.228	1.194	0.223
	C22:2	--	0.254	--	0.739	--	0.111
Total		14.448	18.488	14.9	7.045	15.702	15.079
% of increase or decrease		---	(+)27.96	(+)3.13	(-)51.24	(+)8.68	(+)4.37
Grand Total content		100.001	104.994	100.007	100.000	100.000	99.996
% of increase or decrease		---	(+)4.993	(+)0.006	(-)-0.009	(-)0.009	(-)0.005

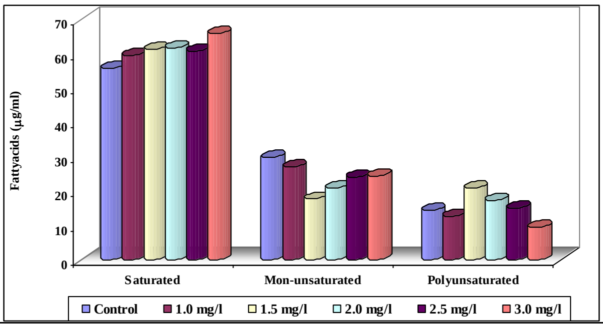

Figure 5: The effect of varying Ni2+ levels on the fatty acid fraction content (μg/ml) of *Spirulina platensis* grown for 10 days.

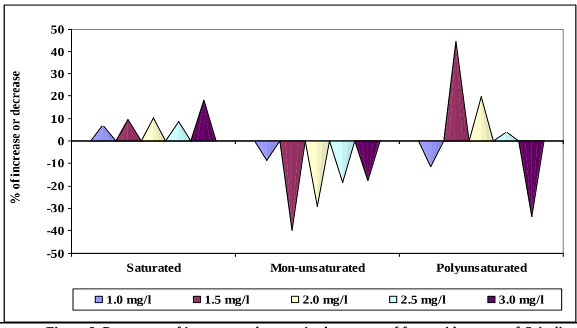

Figure 6: Percentage of increase or decrease in the content of fatty acids groups of *Spirulina platensis* cultured for 10 days under the effect of different Ni2+ concentrations compared to control.

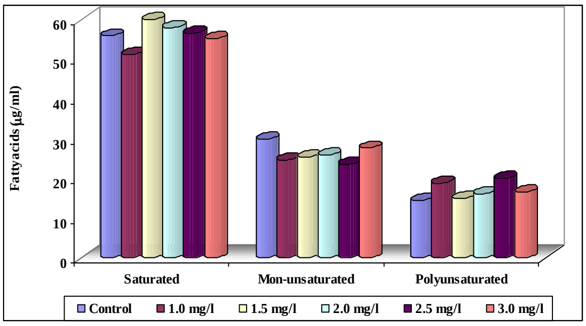

Figure 7: The effect of varying Cu2+ levels on the fatty acid fraction content (μg/ml) of *Spirulina platensis* grown for 10 days.

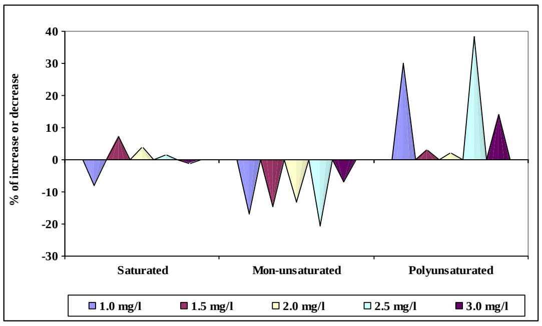

Figure 8: Percentage of increase or decrease in the content of fatty acids groups of *Spirulina platensis* cultured for 10 days under the effect of different Cu2+ concentrations compared to control.

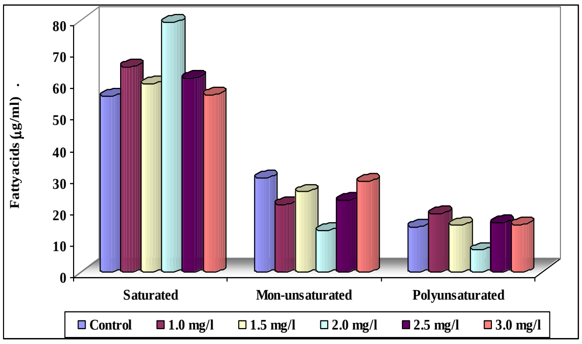

Figure 9: The effect of varying Zn2+ levels on the fatty acid fraction content (µg/ml) of *Spirulina platensis* grown for 10 days.

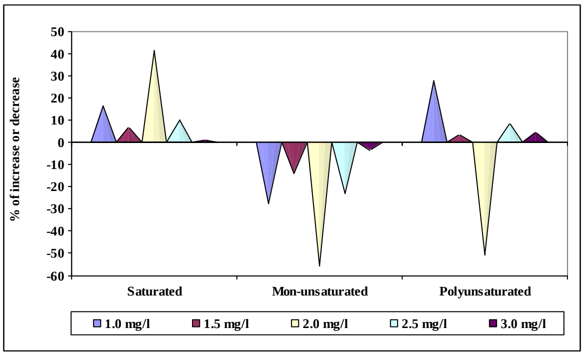

Figure 10: Percentage of increase or decrease in the content of fatty acids groups of *Spirulina platensis* cultured for 10 days under the effect of different Zn2+ concentrations compared to control.

D- Protein profile:

The total soluble protein profile on the gel plate for the control and treated organisms at various concentrations of Ni^{2+}, Cu^{2+}, and Zn^{2+} (1.0, 1.5, 2.0, 2.5, and 3.0 mg/l) revealed bands that were dispersed throughout the gel plate. There were 20 bands for Zn^{2+} and 17 bands for both Ni^{2+} and Cu^{2+} that were observable on the gel plate and confirmed by scanning utilising the band peaks. Under the influence of different concentrations of the three tested elements (Ni^{2+}, Cu^{2+}, and Zn^{2+}), some of these bands were common in both the control and the treated organism, while others were frequent only in the treated organism. Nearly all of the lanes saw the majority of them in the area between 25 KDa and 212 KDa. However, at all Ni^{2+}, Cu^{2+} and Zn^{2+} concentrations, the number of these bands often increased as the element's concentration increased, (**Fig. 11- 13**). Cu^{2+} stress had a greater impact than Ni^{2+} and Zn^{2+} stress on the protein profile in terms of the damaging effects of the heavy metal ions. These findings appeared to be consistent with those of several previous works (**Ahmed, 2010 ; El Taher, 2012 and El-Agawany and Kaamoush, 2022**).

However, the majority of the bands were visible in almost every lane between 25 KDa and 212 KDa. There were only 13 bands acquired for the control, whereas the number of bands varied depending on the kind and concentration of the material being tested. In the case of Ni, the sum of the bands increased as concentration of the element increased. At concentrations of 2.0, 2.5, and 3.0 mg/l Ni, the percent of increased bands reached 30.8% over control for all three of the tested concentrations of Ni, whereas at concentrations of 1.0 and 1.5 mg/l Zn, the percent of increase in the total of bands was 15.4%. At concentrations of 1.0 and 1.5 mg/l Ni, there were 3 freshly formed bands; at values of 2.0, 2.5, and 3.0, there were 4 newly formed bands. This data makes it evident that the majority of freshly produced bands were found in low molecular weight regions, whereas the majority of bands that vanished were found in high molecular weight regions.

The acquired protein profile bands are scattered across the entire gel plate, as shown by these data. The majority of bands have cathodic anodic symmetry, while some bands are anodic and others cathodic. There were 20 bands for Zn and 17 bands for both Ni and Cu that were visible on the gel plate and confirmed by scanning utilising the band peaks. Under the influence of the five different concentrations of the three tested elements (Ni^{2+}, Cu^{2+}, and Zn^{2+}), some of these bands were common in both the control and the treated organism, while others were frequent only in the treated organism. Another crucial statistic is that *Spirulina platensis* has an overall protein content of 82.63% in 50% wastewater effluent. It has been hypothesized that heavy metals in wastewater, even in small amounts, can speed up protein synthesis in *S. platensis*, (**Balaji *et al*., 2015**).

It is also evident that the newly generated bands increased in number from one to three when the Cu concentration was increased from 1.0 mg/l to 2.0 mg/l, two bands at 2.5 mg/l, and one band at 3.0 mg/l, respectively. Additionally, the total bands rose to 15 bands for Cu at concentrations of 1.0, 1.5, and 2.5 mg/l, and to 16 bands at 2.0 mg/l of Cu. At a concentration of 3.0 mg/l Cu, there were only 14 bands. In the instance of Zn, the number of bands grew as element concentration increased. At 2.0, 2.5, and 3.0 mg/l Zn, respectively, the newly generated bands rose by almost 5, 3, and 4 bands as the element concentration increased. Only one band vanished at Zn values of 2.0 and 2.5 mg/l. The sensitivity of *Spirulina platensis* to Cu, Zn, and eventually Ni ions may be explained by this map. **El-Agawany and Kaamoush (2022)** found that the toxicity of the zinc element affected the percentage growth in the number of bands in *Dunaliella tertiolecta* culture were verified. It is also apparent that the organism experienced severe harm as a result of the zinc element's toxicity at a dosage of 25 mg/L.

The protein profile of algae can also be impacted by various heavy metals. **Chernicova *et al*., (2006)** indicated that increasing manganese concentrations did not significantly alter cell ultrastructure or protein profile in *Spirulina platensis*. **Sinha and Hader, (1996)**, observed that *Anabaena* species cultured exhibited no changes in protein pattern under stress. On the other hand, **Fulda *et al*., (1999)** reported that Periplasmic proteins isolated from culture of *Synechocystis* species cultured under metal stress showed substantial changes in composition. **Hoyos and Zhang, (2000)** findings that coincide with the conclusions above) discovered that reversible protein phosphorylation/dephosphorylation is crucial in signaling the plant's adaptive response to stress. The results of **Salah El-Din, (1994)** findings supported the idea that most algae species share physiological processes that are connected to the creation or breakdown of certain macromolecules. This finding appears to explain the various variations in total soluble protein band amounts in stressed algae.

Ahmed, (2010) and El Taher, (2012) noticed that the synthesis or accumulation of new proteins could be used to increase an organism's resistance to stress circumstances. These findings closely match those we obtained for *Spirulina platensis*. The majority of developing nations are very concerned about the lack of protein in human nutrition, hence new, unconventional protein sources must be developed. *Spirulina platensis* and other microalgal species, in particular, have a high protein concentration, which makes them a good source of this nutrient, (**Anne *et al*., 2016**).

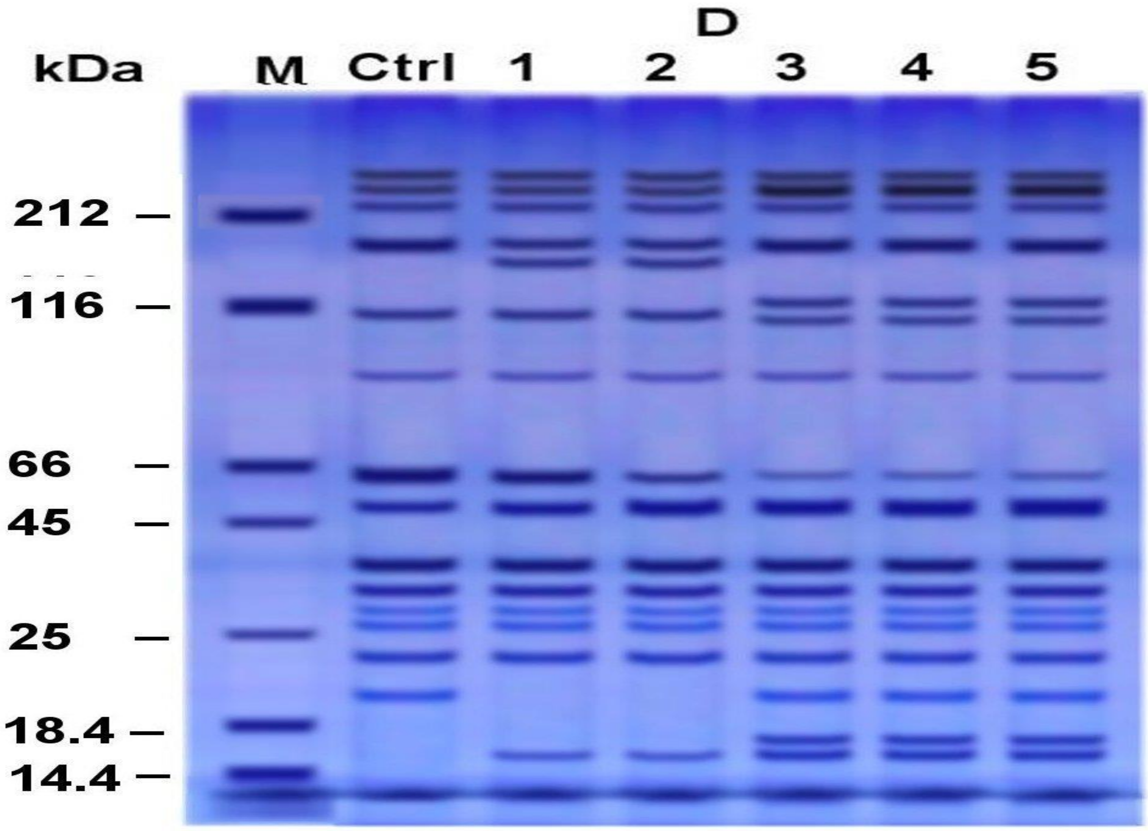

Plate 1: Soluble protein profile bands pattern of the studied *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Ni^{2+} concentrations. (Lane 1 (M) = marker; lane 2 (Ctrl) = control; lane 3 (1) = 1.0 mg/l Ni; lane 4 (2) = 1.5 mg/l Ni; lane 5 (3) = 2.0 mg/l Ni; lane 6 (4) = 2.5 mg/l Ni; lane 7 (5) = 3.0 mg/l Ni).

Table 4: Soluble protein profile pattern bands showing sum, unchanged, disappeared and newly formed bands at control and under the effect of different Ni^{2+} concentrations.

Treatment / Bands	Control	Different Ni^{2+} concentrations (mg/l)				
		1.0	**1.5**	**2.0**	**2.5**	**3.0**
Sum of bands	**13**	15	15	17	17	17
Unchanged bands	--	12	12	13	13	13
Disappeared bands	--	1	1	0	0	0
Newly formed bands	--	3	3	4	4	4

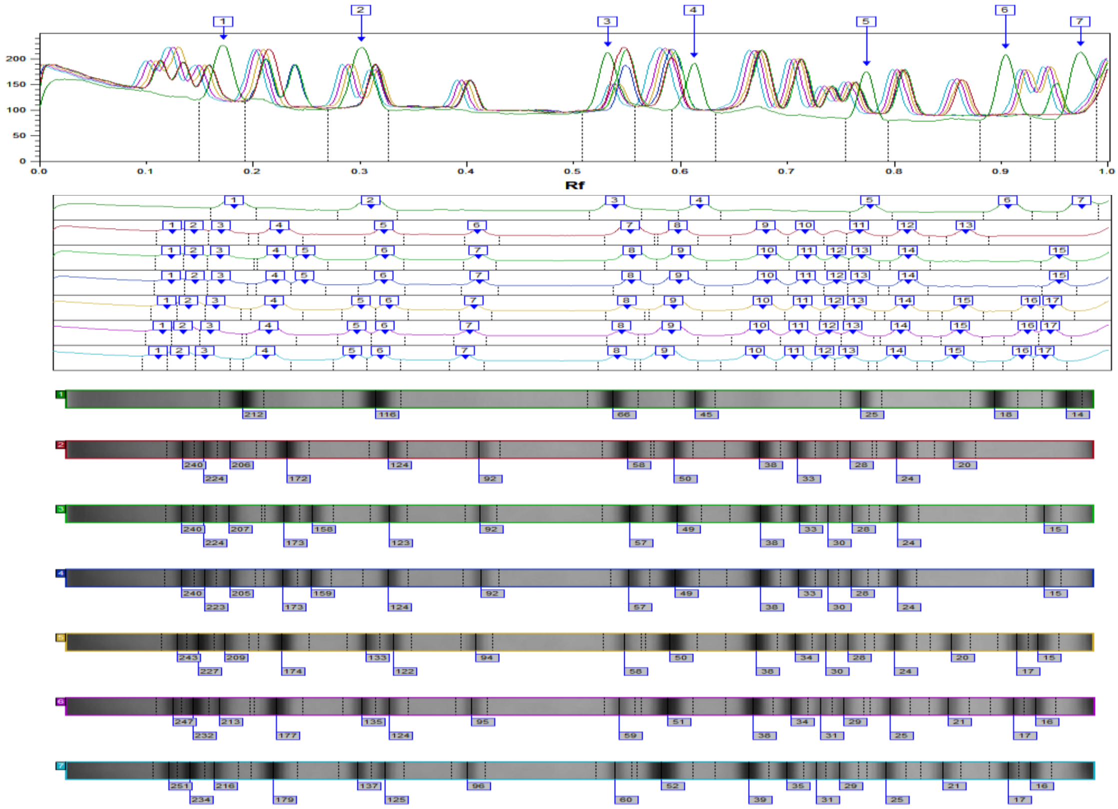

Figure 11: Electropherogram showing the results of scanning of protein profile bands of *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Ni^{2+} concentrations.

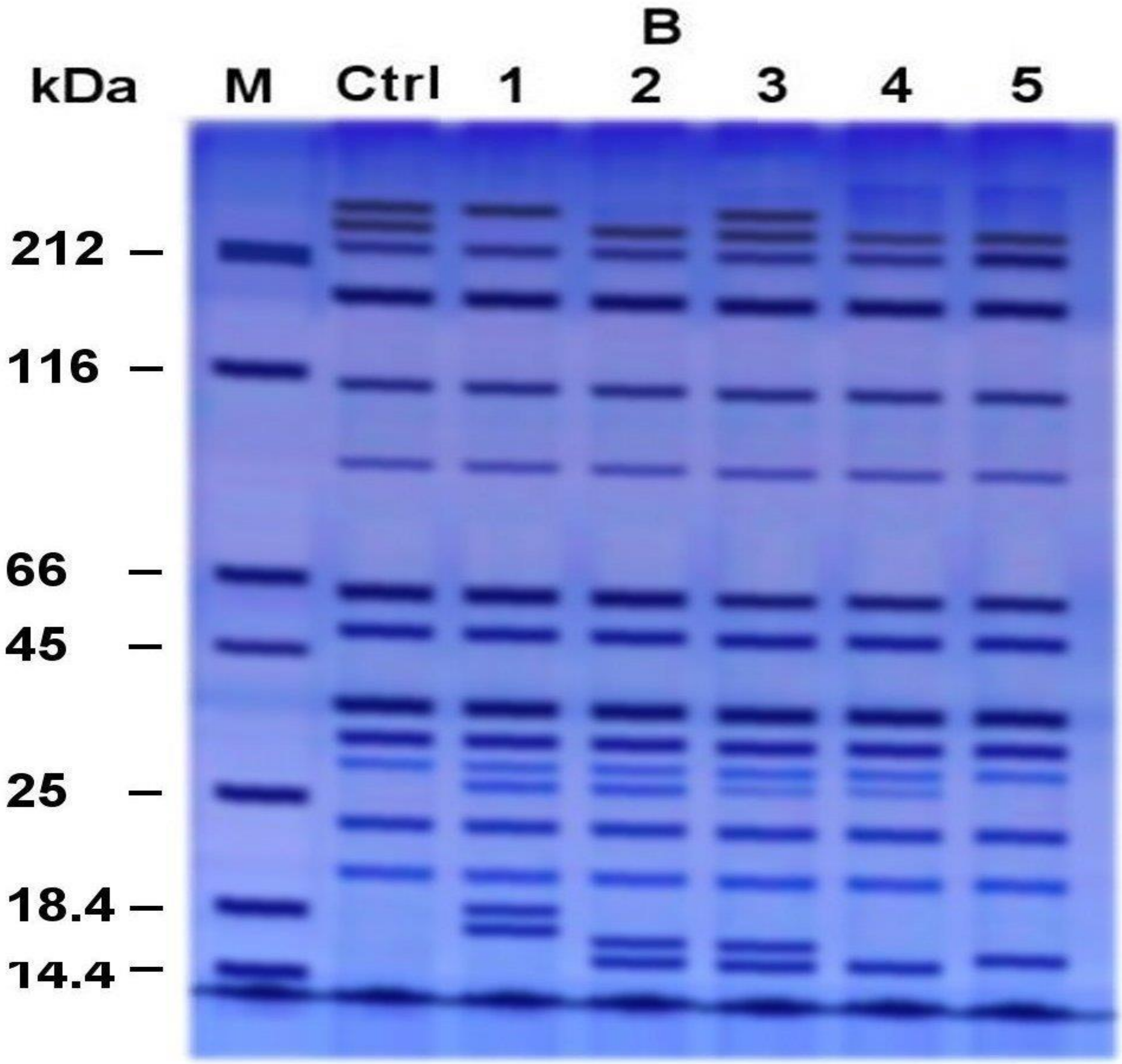

Plate 2: Soluble protein profile bands pattern of the studied *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Cu^{2+} concentrations. (Lane 1 (M) = marker; lane 2 (Ctrl) = control; lane 3 (1) = 1.0 mg/l Cu; lane 4 (2) = 1.5 mg/l Cu; lane 5 (3) = 2.0 mg/l Cu; lane 6 (4) = 2.5 mg/l Cu; lane 7 (5) = 3.0 mg/l Cu).

Table 5: Soluble protein profile pattern bands showing sum, unchanged, disappeared and newly formed bands at control and under the effect of different Cu^{2+} concentrations.

Treatment / Bands	Control	Different Cu^{2+} concentrations (mg/l)				
		1.0	1.5	2.0	2.5	3.0
Sum of bands	**13**	15	15	16	15	14
Unchanged bands	**--**	12	12	13	13	13
Disappeared bands	**--**	1	1	0	0	0
Newly formed bands	**--**	3	3	3	2	1

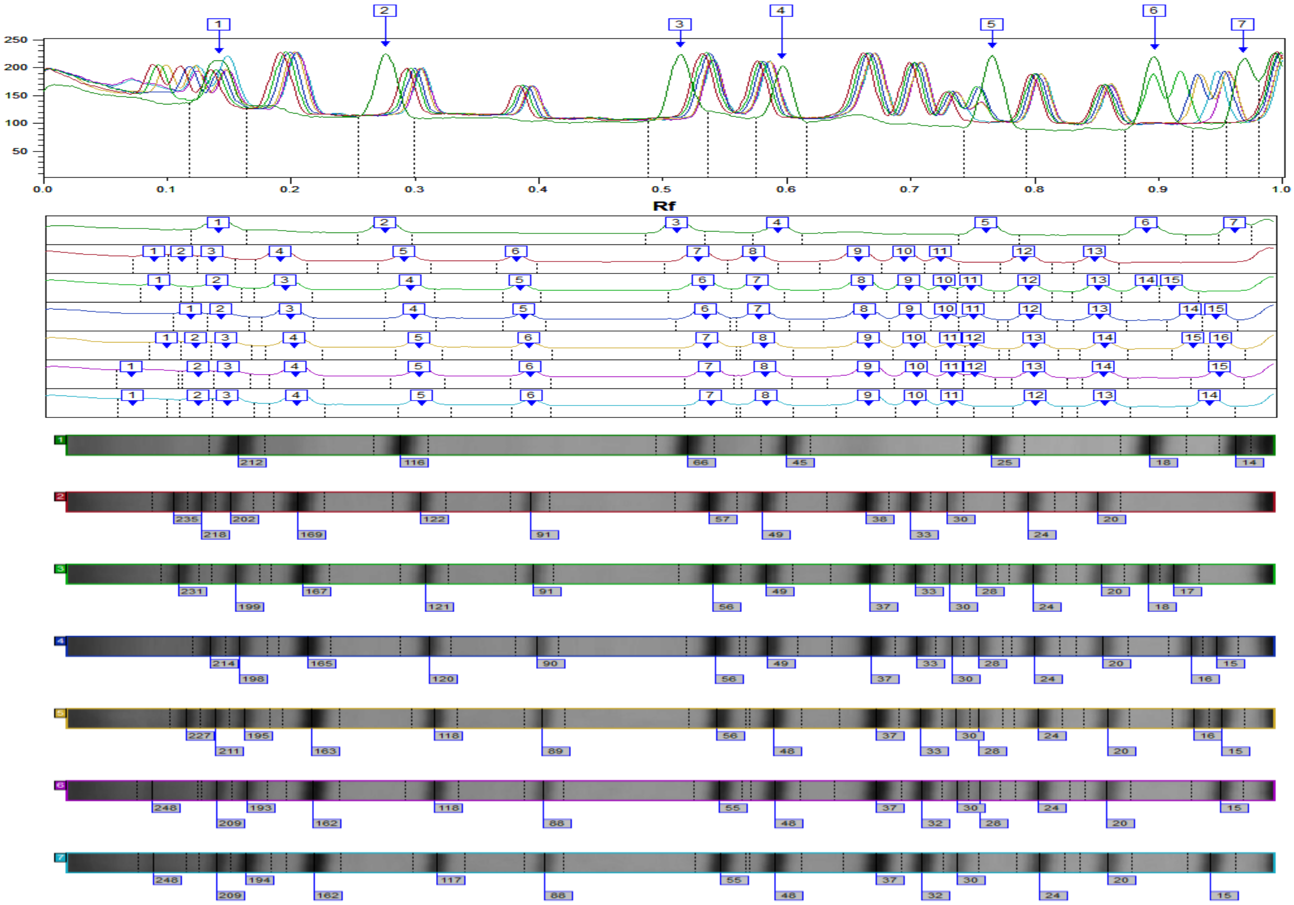

Figure 12: Electropherogram showing the results of scanning of protein profile bands of *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Cu^{2+} concentrations.

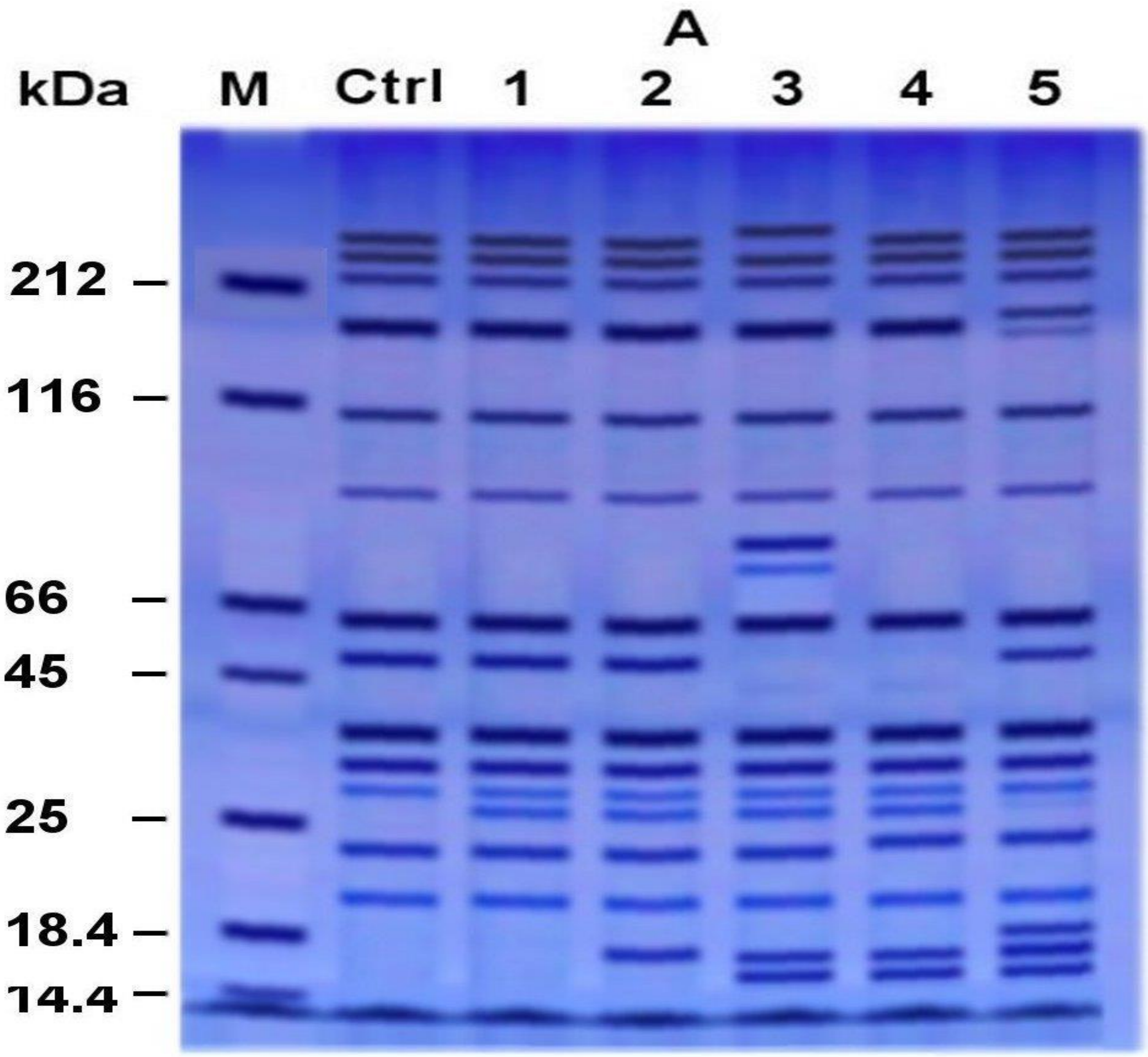

Plate 3: Soluble protein profile bands pattern of the studied *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Zn^{2+} concentrations. (Lane 1 (M) = marker; lane 2 (Ctrl) = control; lane 3 (1) = 1.0 mg/l Zn; lane 4 (2) = 1.5 mg/l Zn; lane 5 (3) = 2.0 mg/l Zn; lane 6 (4) = 2.5 mg/l Zn; lane 7 (5) = 3.0 mg/l Zn).

Table 6: Soluble protein profile pattern bands showing sum, unchanged, disappeared and newly formed bands at control and under the effect of different Zn^{2+} concentrations.

Treatment / Bands	Control	Different Zn^{2+} concentrations (mg/l)				
		1.0	**1.5**	**2.0**	**2.5**	**3.0**
Sum of bands	**13**	14	15	17	15	17
Unchanged bands	**--**	13	13	12	12	13
Disappeared bands	**--**	0	0	1	1	0
Newly formed bands	**--**	1	2	5	3	4

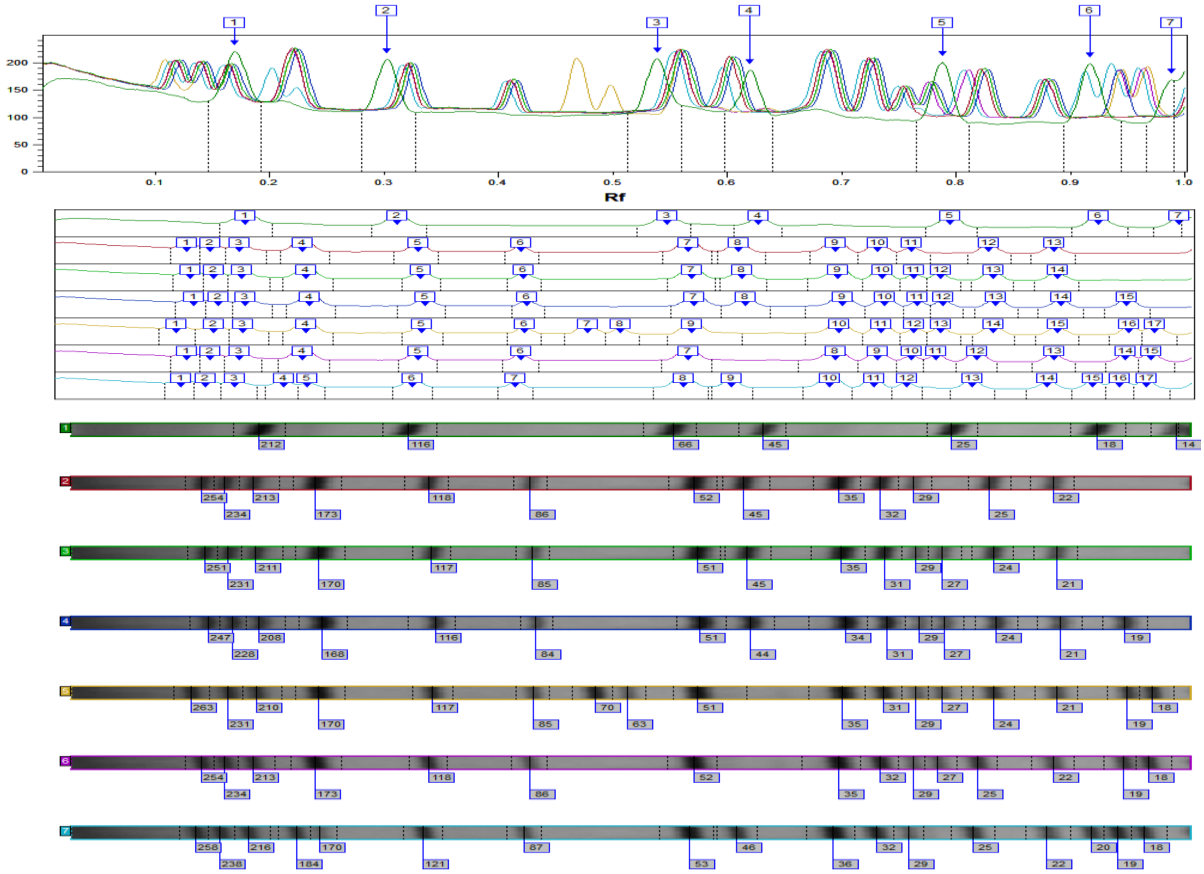

Figure 13: Electropherogram showing the results of scanning of protein profile bands of *Spirulina platensis* cells cultured for 10 days on control and under the effect of different Zn^{2+} concentrations.

CONCLUSION

Growth of *Spirulina platensis*, IR spectra, content of fatty acid fractions, and total soluble protein profile were all affected by the effects of various concentrations of Ni^{2+}, Cu^{2+}, and Zn^{2+}, and the results showed that the EC50 for all three heavy metals was almost recorded at a concentration of 2.0 mg/l. Optical density measurements showed that copper had a highest growth inhibitory impact than zinc or nickel did at all of the tested doses. IR spectra data indicated that novel compounds were generated in treated cells as opposed to untreated cells, and as a result, new peaks in the spectra developed while other compounds vanished. Compared to Zn^{2+} and Ni^{2+}, this was clearer in the case of Cu^{2+}. Harmful effects of the three elements changed depending on the type of fatty acid group. As a consequence, the overall amount of the three fatty acids groups was decreased as the element's concentration was raised. Total fatty acids decreased under stress at all concentrations examined, and saturated fatty acids outnumbered unsaturated fatty acids. Cu^{2+} stress was more significant than Zn^{2+} and Ni^{2+} stress in terms of the detrimental effect of metal ions on protein profile. The production or accumulating of new proteins may increase an organism's resistance to stressful situations. The sequence of toxicity of the three heavy metals ions is Cu^{2+} in the first order, followed by Zn^{2+} and Ni^{2+} at all examined concentrations, indicating that Cu^{2+} is more toxic than Zn^{2+} and Ni^{2+} metal ions and that the degree of stress is primarily influenced by the concentration and type of element as well as the duration of the culture period. The majority of developing countries are very concerned about protein deficit in human nutrition, hence new unorthodox protein sources must be created. Different microalgal species, especially *Spirulina platensis*, have a high protein content, which makes them ideal sources of this nutrient.

Ethical Approval: Not Applied

Consent to Participate: I freely consent to take part in this research study.

I understand that even if I accept to participate now, I have the right to withdraw at any moment or choose not to answer any question without consequence.

Consent to Publish: The authors warrant that the work has not been previously published in any form and is not being considered by another publisher, that the above-mentioned individuals are listed in the correct order, that no author entitled to credit has been omitted, and that the authors have the right to make the grants made to the Publisher complete and unencumbered.

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Authors Contributions: N.I.A., M.I.A.K. and H.E. contributed equally to the manuscript preparation. N.I.A., M.I.A.K. and H.E. designed the experiment and performed the laboratory analyses. N.I.A., M.I.A.K. and H.E. carried out the statistical analyses and tabulated the study results. N.I.A., M.I.A.K. and H.E. wrote the first draft and revised the final version of the paper. N.I.A., M.I.A.K. and H.E. read and agreed on the submitted paper.

Funding: No funding was received.

Competing Interests: he authors state that they do not have any competing interests.

Availability of data and materials: This article includes and makes accessible all of the data produced or analysed during this investigation.

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Innovative Strategies for Enhancing Port Competitiveness

An Overview of Applying Lean Principles to Shipbuilding

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Keywords: Lean Thinking, Process Flow, Lean Manufacturing, Group Technology.

1. ABSTRACT: This study attempts to find and define the concept of lean manufacturing as one of the engineering management strategies that can be used by Egyptian shipyards to help them compete in this global shipbuilding market. It has been noticed from previous cases in world-class shipyards that using tools such as just-in-time, one-piece flow, and takt-time as a suite of lean manufacturing techniques helped improve product cycle times and quality by eliminating waste in the manufacturing processes. These techniques have also become the basis for lean manufacturing in the world. So, to assist Egyptian shipyards in deciding how to respond to lean shipbuilding, this study provided a comprehensive overview of the potential applications of lean manufacturing principles as a roadmap for those looking to implement it. Also, the method of introducing lean manufacturing was explained in a way that suits the Egyptian culture, as Egyptian shipbuilders rely mainly on the professionality of the workers but not the use of robots, as is the case in European shipyards. that makes the Egyptian shipbuilders think to implement the principles of lean manufacturing which is known now as lean shipbuilding. in addition, proposed procedures deal with some engineering management procedures that mean shipbuilders will not have to invest more money to get. an example of applying lean manufacturing tools through a block assembly line at one European shipyard has been presented.

2. INTRODUCTION

The global shipbuilding market was approximately 132.52 billion USD in 2021, and it is anticipated to reach 175.98 billion USD by 2027, according to the Industry Analysis Report 2021–2027. Furthermore, the article states that Daewoo Shipbuilding & Marine Engineering obtained orders worth $5 billion USD in February 2022 to construct two LNG carriers and six container ships for a European shipper. Also, Six brand-new LNG-fueled vehicle carriers will have their fuel gas supply systems ordered from Mitsubishi Shipbuilding in December 2021. China State Shipbuilding Corporation announced a significant set of vessel newbuilding orders in December 2021 for the construction of eight vessels and eight contracts for marine equipment projects totaling 1.9 billion USD.

The 1990s saw the publication of the book The Machine That Changed the World: The Story of Lean Production, which is when the phrase "Lean Manufacturing" first appeared. (Womack J.P. et al.,1991) The movement of manufacturing concepts from worker-based production through mass production to lean production is continued in this book. Although it has its roots in the automotive sector and the Toyota Production System, other production lines are now using it. Lean Manufacturing aims to decrease waste, boost efficiency and production, add value, lower costs, and boost competitiveness. achieving consumer satisfaction is the goal of this.

Lean manufacturing, which was first introduced within the Toyota Production System, is becoming more and more popular among manufacturers and across all industries. And this is not done by adding new methods to the way products are made, but by changing the way of thinking about production processes. And while switching to lean shipbuilding can be challenging, the results prompt shipyards to try it. The fact that ships are custom build projects makes the use of lean manufacturing principles in the shipbuilding sector particularly challenging. Probably not all of Toyota's lean tool application techniques will apply to shipbuilding, but the philosophy and principles can be applied with some adjustments. It is possible to observe a lot of the same principles used in the Toyota production system at work in shipyards by looking at models of world-class shipbuilding. For instance, Japanese shipyards use largely standardized modular designs with a steady flow of basic and intermediate products. Materials are precisely sequenced and moved through the shipyard using the Just-In-Time principle. also, instead of being examined, quality is built in at the production workstation. Processes are timed using takt time and are highly standardized. steel plates are brought in as just-in-time Instead of being transported into the stockyard months in advance.

The research problem is that Egyptian shipyards have not yet entered the global market, preferring to supply the domestic commercial and military markets. Despite advancements in the field of standardization and standardized production directed by intermediate products generated by the Egyptian shipbuilding industry. Its overall integration level is still below the world-class level. Additionally, the majority of shipyards still employ the conventional intensive production management technique. The competitive advantage declines as labor expenses rise.

Egyptian shipyards must adapt their manufacturing processes and rely on lean manufacturing philosophies and practices as a result of steps taken to increase their competitiveness. The Toyota production system, the underlying lean concepts, and the best applications of the lean methodologies, according to the author, will serve as a platform for modernizing the production processes used in Egyptian shipyards. This paper provides a framework for using the lean shipbuilding process' ideas. that is with the assumption that the ship is built to be producible according to lean principles is necessary for the application of these principles. The lean shipbuilding model will be used to describe the lean manufacturing philosophy. Additionally, some outstanding shipbuilding examples will be provided.
Egyptian Shipyards should increase productivity and shorten the production cycle in order to survive and become more competitive (JEFFREY K. LIKER 2004). using Lean manufacturing as an engineering management strategy to eliminate waste is one of the objectives of this lean thinking, which can improve customer satisfaction and turn waste into value.

2. LEAN SHIPBUILDING OVERVIEW

2.1 Lean shipbuilding Philosophy

Because it utilizes less of everything than the mass production method, this system is known as the "lean manufacturing system." To build a new ship in half the time, lean manufacturing uses half the labor force in the facility, half the manufacturing area, half the tool investment, and half the engineering hours. Toyota's Production System is based on14 principles under four sections, all beginning with the letter P. (Sharma, S., & Gandhi, P. J.2017). (Philosophy) each organization must have a long-term philosophy. (Process) The right steps will produce the right outcomes. (People) By improving their work, they must bring value to the organization. (Problem-Solving) Regular problem-solving results in structured learning. Eliminating the Eight Waste Elements has become the core of lean shipbuilding.

2.2 Lean Manufacturing processes

lean manufacturing processes are:
i) Identify value. This can be done using value management, and simulation.
ii) Map the value stream to make the product defined as the value flow.
iii) If at all possible, develop a process flow to avoid or minimize batch and queue.
vi) Establishing a pull system by adjusting production to customers' needs.
v) Seek perfection and continuous improvement.
Lean manufacturing seeks to shorten lead times and eliminate all forms of waste from the production process (Phogat, S. 2013). Lean production is achieved through a variety of technologies, including JIT, Kanban, cellular manufacturing, total production maintenance, kaizen, and 5s (Liker. J, and T. Lamb,

2002). In order to attain uniform production directed by intermediate products, industrialized nations like the United States, Japan, South Korea, and others have taken the lead in applying the philosophy of lean manufacturing to the shipbuilding sector since the 1980s. Lean manufacturing is a different production system that was established by Henry Ford on the Ford Motor Company's moving assembly line. The majority of industrial companies that specialize in important industries like cars, aircraft, paint, computers, and furniture are moving in that direction (Womack, J. P., et al., 1991).

2.3 Definition of Waste in lean system

Numerous manufacturing processes present the possibility of waste issues impacting worker productivity, product quality, costs, and production time (Fitriadi et al, 2021). Waste in lean shipbuilding is anything that increases the time and expense required to build the ship but does not improve its value in the eyes of the customer. Value-added activities make the product a desirable item for the customer. Figure 1 shows simplified steps required to sub-assemble the ship hull steel plates. Only activities displayed in dark green add value. The light green dotted activities do not add value from the customer's point of view. Since the value-added time makes up a small portion of the overall time limit, it is evident from Figure.1 that the overall benefit of cutting cycle time value-added activities is only up to a small portion of the time total. The efficiency of value-added activities may be attacked, as may be anticipated from mass productive thinking. One may, for instance, shorten the cycle time required to cut steel.

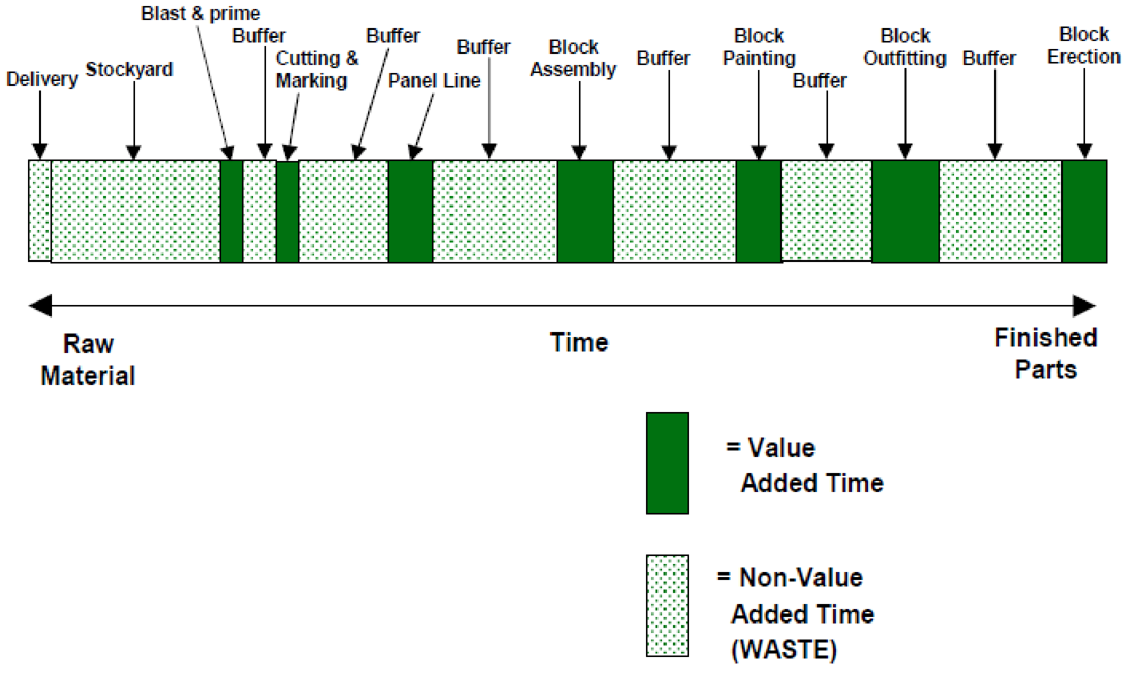

Figure 1 Elements of shipbuilding Lead-time (Liker,2002)

2.4 Lean Thinking

Lean thinking emphasizes the flow of added value and system effectiveness. The objective is to keep the product flowing and add value as much as possible, thus any portion that is in inventory is waste. (Poppendieck, 2002). The overall system and synchronized procedures are the main areas of concern to ensure that they are coordinated and produced at a steady rate. Lean shipbuilding is a manufacturing concept that, by removing waste, shortens the time between a customer's order and ship delivery. Figure 2 shows the results of the lean approach (Smith A, T. Y. 2015). Lean manufacturing decreases activities that are not just value-added, which has a bigger impact on lead time than reducing waste from value-adding activities, which will reduce waste as in the mass production strategy.

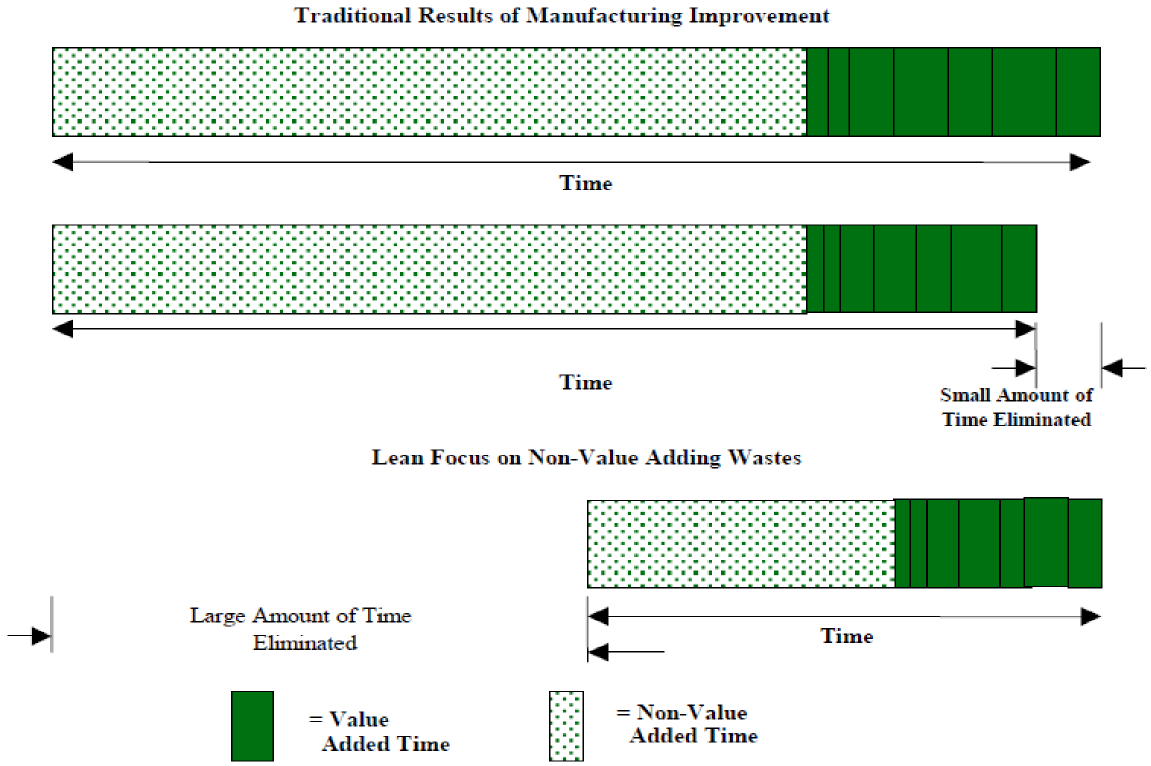

Figure 2 Traditional thinking vs Lean thinking (Liker, 2002)

2.5 The Eight Elements of waste (Liker. J, & T. Lamb, 2002)

i) Overproduction - the act of producing more than is required before it is required.

ii) Inventory - materials take up space, cost money, it is likely to be damaged.
iii)Waiting - waiting for materials, processes, or machines.
vi. Movement- any motion does not add value.
v. Transportation- transportation does not improve the value of the product.
vi. Defected product- unnecessary redundant operations to fix detects are waste.
vii. Over-processing- more work than the customers require.
viii. misallocated personnel- failure to allocate workers to work represents a kind of waste.

2.5.1 Overproduction in shipbuilding

In shipbuilding processes, the completion of the set of components naturally affects how quickly operations can begin. For instance, starting a block assembly requires the completion of all block components. But there is a possibility that a component was produced early waiting to produce other components to be processed in the next process. this condition is called shipbuilding overproduction. Overproduction refers to the production of components or work-in-process stocks too early, or too much (Ge and Kim, 2014; Harrison et al., 2014). Overproduction is the early termination of operations at a workstation in the shipbuilding industry, Reducing overproduction enhances production performance while also allowing the production line to get rid of surplus inventory (Longva, 2009). Overproduction has a detrimental impact on productivity and quality by causing an uneven material flow, which is the main source of waste (Harrison et al., 2014). Resources become more scarce for other uses because overproduction uses them up before they are needed. Furthermore, in this scenario, where the operational facilities are occupied by excess production, the overall cost of waste rises. Additionally, the utilization of resources for overproduction may result in an extension of the project's timeline. (Koskela, 2000), (Shahsavare, et. al 2021).

2.5.2 Waiting time in shipbuilding.

In shipbuilding operations, there is a high likelihood of waiting for work-in-process. For instance, a set of sections may be ready to form a block, but all the workstations may be occupied, or a sizable block may be waiting in line to begin the hull construction phase because there aren't enough workstations. The ineffective use of time in production processes is referred to as "waiting " as waste. (Harrison et al., 2014). When an activity is waiting to be processed because a workstation is not accessible, it is referred to as a wait in the shipbuilding industry. Waiting can drastically slow down production flow in the shipbuilding industry (Liker and Lamb, 2002). Waiting times do not allow for the best use of the scarce capital that some types of workers have access to in shipbuilding (Lee et al., 1996). Waiting for waste not only drives up overall shipbuilding costs but also lengthens project timelines (Koenig et al.,2002; Shahvari) , (Logendran, 2017).

2.6 Built-in quality

Built-in quality is superior to quality inspection and repair, and it is also less expensive. A set of statistical and problem-solving techniques that can assist in completing the task successfully are referred to as precision control, a phrase used in the shipbuilding industry. In the lean system, there is no buffer to use in the event of a quality issue due to the extremely low stock levels. Process B will abruptly cease if process A has issues, which is a problem made worse by a chain of processes. Figure 3 illustrates the issue of serial unreliability, which can lead to decreased system reliability overall. Four individually reasonably reliable processes (85% to 90% dependable) can cause this (62%). the concept of built-in quality is to allow only good parts to pass on to the next process. On occasion, a problem will arise, and if it is not swiftly fixed, it could shut down downstream activities. Therefore, the production line needs a mechanism to rapidly identify the issue and shut down the line in order to stop producing more defective parts.

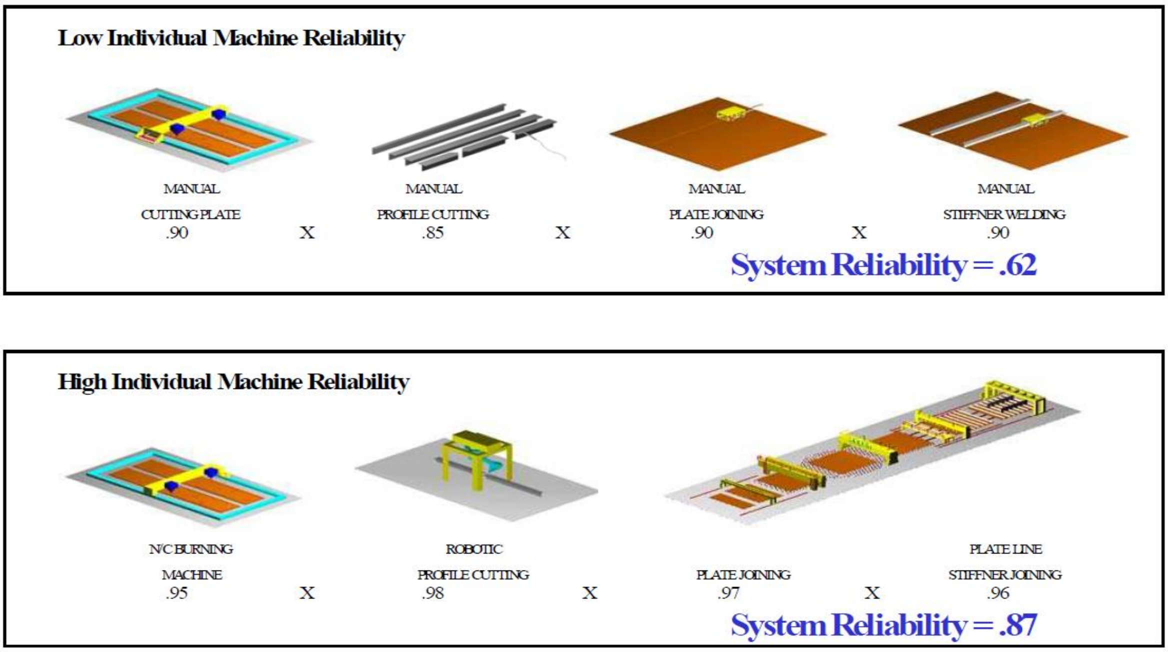

Figure 3 problem of serial unreliability (Liker, 2002)

2.7 Five S System

The stability of the workplace depends on its organization. Visual control can be exercised since it is easy to spot deviations from the standard when there are clear criteria for where objects belong. Lean 5S Manufacturing System is used to maintain cleanliness and order in the workplace:

Sorting- involves classifying goods, keeping only what is necessary, and getting rid of the rest.

Sort the items in the yard first, putting a red flag on everything that is rarely or never utilized and separating what is needed every day to accomplish value-added work from what is not. then bring them outside to the main holding area where it is assessed further. The other stuff is thrown away, while the usable items are organized at the store.

Straighten - assign a place for everything and everything in its place.

once items are narrowed down to those in regular use, they can be arranged close to where they are used and labeled so that it is easier to identify ideally. All materials must be well organized and use efficient storage procedures, use floor coatings, delineation work areas and locations, and shade boards.

Sweep - a type of inspection that reveals unusual circumstances and early failure.

The workspace must be completely cleaned after the clutter has been cleared away and the workspace has been organized, and keeping its cleanliness must become a regular habit.

Standardize (creating rules)

After accomplishing the first three S, it is vital to standardize the best practices to improve the operations' sustainability and achieve control over the first three S.

Sustain - maintaining the new quality through the upkeep of a steady workplace.

The process of constant improvement is continued in this cycle. Employees can easily pull things back since rigid procedures are difficult to change, making staying with the changes that have been made the hardest thing to do. For this reason, it's crucial to understand and improve the changing processes.

2.8 Best Practices of Lean Shipbuilding

The application of Lean principles in shipbuilding is not well documented in the literature. This is not to say, however, that there aren't plenty of instances from the shipbuilding sector where lean principles have been successfully applied.

i- Lean Shipbuilding in Japan (Phogat, S. 2013) By successfully implementing lean concepts and achieving improved production, product quality, and the exploitation of human resources, Japanese shipyards are now considered "role models" in the industry. Japanese shipyards are therefore regarded as being the best examples of lean thinking in shipbuilding. To the extent that it was practical, Japanese shipyards used JIT and a one-piece flow. Numerous circumstances now incorporate both lean manufacturing and Total Quality Management. (Koenig, p.c. et al. 2002).

ii- Lean shipbuilding in Norway (Bertelsen, Sven 2007) The shipbuilding industry in Norway is renowned for producing highly customized goods with a high level of outsourcing and little standardization. The combination of lean manufacturing and lean construction has been embraced by Norway Shipyard as a result of this specialization as a completely new idea of lean shipbuilding. The production and warehouse sectors also employ 5S. To enhance procedures, they use Value Stream Mapping.

iii-Lean shipbuilding in the U.S. (Liker. J, and T. Lamb, 2000) Lean Shipbuilding is a project that the National Shipbuilding Research Program has launched to increase efficiency and cut costs. Despite advancements in facilities and procedures, the U.S. Shipyard's performance is still subpar when compared to Japan and Korea, but there are huge gains to be made by fully implementing lean manufacturing principles.

iv-A shipyard in Mississippi (Liker, J.K. 2006) Lean was actively applied in the year 2000, and the outcomes were reported as a lead time reduction of 54%, a rework reduction of 80%, and a Productivity improvement of 29%, as well as the establishment of a Standardized work procedure for label plates.

v-Puget Sound Naval Shipyard By implementing one-piece flow in operations, improvements were made that resulted in a 60 percent decrease in non-value-added time, a 95 percent decrease in wait time, a 73 percent decrease in total lead time, a 70 percent decrease in paperwork travel distance, a 67 percent decrease in process steps, and an 80 percent decrease in workstations.

3. ROADMAP TO LEAN SHIPBUILDING

3.1 Build flexible, motivated, and capable Teamwork.

More reliance on humans, not less, is the result of lean manufacturing. A combination of committed management, suitable training, a culture that encourages the ongoing improvement of normative behavior, and the involvement of all employees are required to achieve this. An organizational structure based on work teams is necessary for maximizing employee engagement. Determining the workload involves operators who have been jointly taught, as well as job rotation and employees with the flexibility and ability to switch between operations.

3.2 Use the Just-in-Time technique.

By obtaining the correct amount of raw materials and creating the right amount of goods at the right time and location, the just-in-time manufacturing principle helps to reduce waste (Phogat S 2013 b)**.** The ideal for an on-demand production system is a one-piece flow (Kolich,et al.2012). Although this method is primarily used for mass production, elite shipyards, particularly Japanese yards, have adapted it. Therefore, a one-piece flow, as depicted at the bottom of Figure 4, is the best solution from the perspective of lean manufacturing. In this situation, you can work with one plate and one stiffener at a time, cutting only the material you need to pass it on, finish the cutting, pass it on, put the subassembly

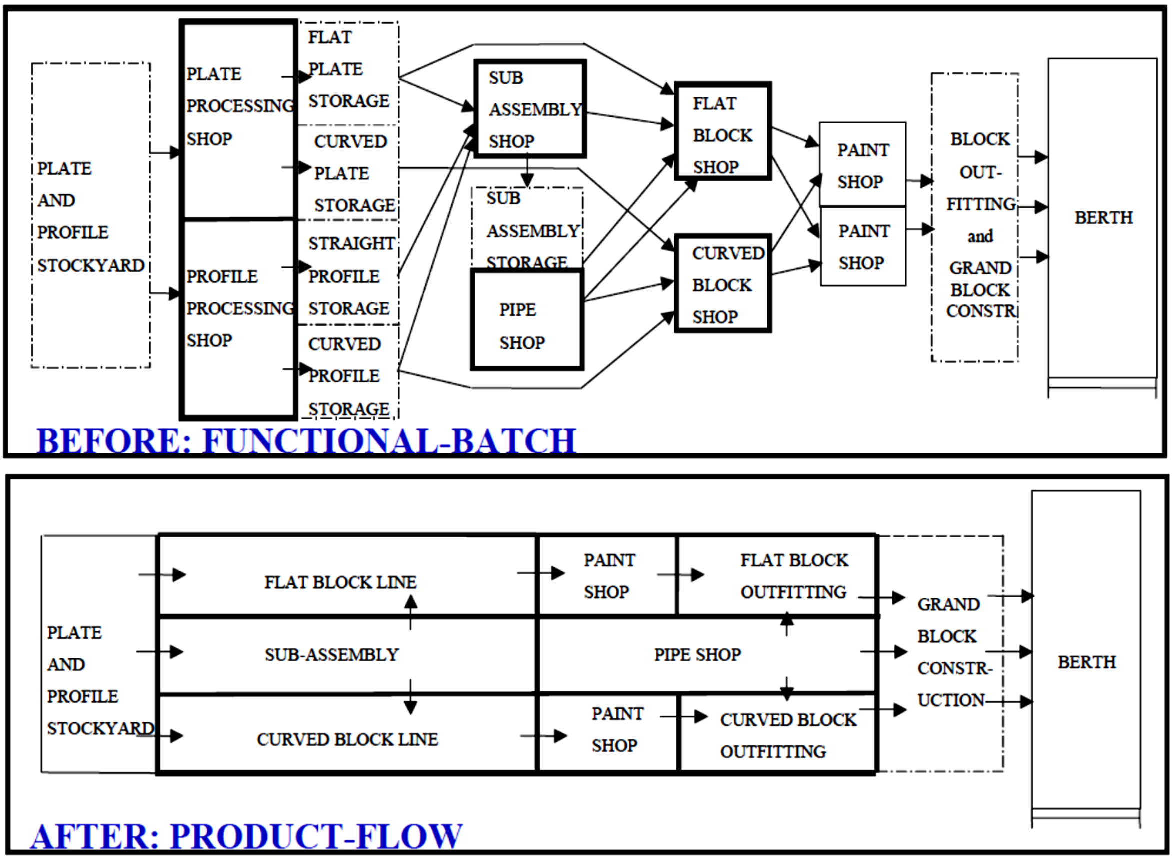

Figure 4 just-in-time in shipbuilding (Liker,2002) together, pass it on, and assemble the block. A larger perspective of the shipbuilding process is shown in Figure 4.

Egyptian shipyards have often been arranged according to their functions. For instance, all structures, whether curved or flat, are created in a separate workshop, and both straight and curved profiles are created in different workshops. large quantities of Panels and profiles are made, which are subsequently put into storage. After that, they are moved to the sub-assembly for sorting. Every component must go through the same paint shop, which frequently turns into a bottleneck. Figure 4's bottom half depicts a configuration that is common in lean shipyards. The yard in this instance is arranged by "product line." A production line does not refer to individual vessels but rather to collections of related components; in this scenario, flat blocks go through one set of operations while curved blocks go through a different set. For instance, all flat panels are cut in process lanes using straight profiles before being transported in tiny lots to the flat block line for assembly. The two separate paint shops are seen in Figure 4; one is for flat blocks and the other is for curved blocks. Then, flat blocks and curved blocks are prepared in different locations before being combined into a huge block assembly.

3.3 Use the Takt time technique.

One of the major advantages of continuous-flow manufacturing is the ability to give clients shorter lead times and enhance the usage of the shipyard, which results in increased revenue. depending on the size and complexity of the ship, Takt time might vary significantly from ship to ship. Similarly, each portion of a ship, which is made up of numerous distinctive components, may have a varied Takt time. It makes more sense to think of the ship as a collection of smaller pieces when considering Takt's period. Think about the following process:

i) How frequently does the ship need to leave the dry dock to meet the delivery timetable, starting with this one? Every six months, all components must be constructed just in time for a ship to emerge from a dry dock.
ii) Next, determine when each component must be finished to satisfy this delivery deadline. as a ship is made up of several different building blocks that must all be constructed simultaneously and more quickly than the ship. As a result, the ship's delivery schedule and the period of time it will be in drydock can be used to establish the block Takt time.

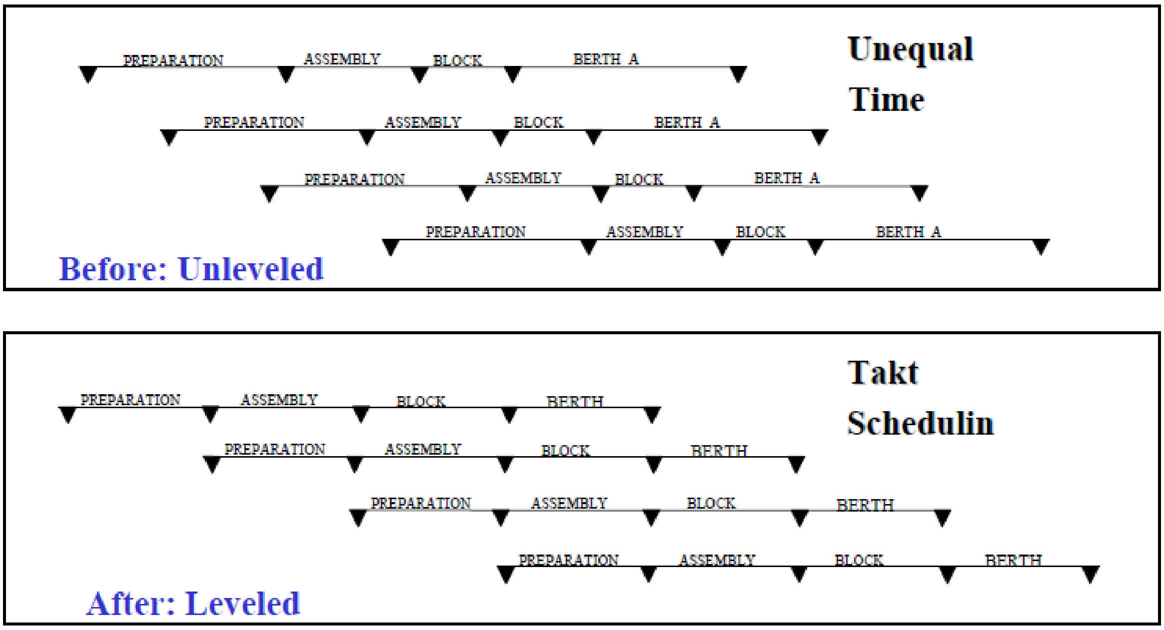

Figure 5 work leveling using Takt time (Liker, 2002)

The block's separate parts are all divided into groups that arrive in time to be assembled before being cut, shaped, and welded. The processing time asymmetry in scheduling is shown in Figure 5's upper portion, where none of the primary products are ready until they are required in later processes. As a result, there will be bottlenecks. The workflow when synchronized using Takt time planning, enables the creation of flows that make the best use of available resources, as shown in Figure 5's lower portion.

3.4 Use the Group Technology technique.

A processing philosophy known as "Group Technology" is founded on the idea that goods should be handled similarly if they are similar. A manufacturing system should be broken down into smaller systems as part of group technology. It decreases set-up time, delivery time, paperwork, tooling, rework, scrap material, and manufacturing lead time. It also decreases labor and work-in-process costs. (Shahin, A., & Janatyan, N. ,2010)**.** The conceptual model for Group Technology is divided into four parts:
i) processes: product categories, a coding system, categorization, design conformity, group production, group technology management, and the automated factory system.
ii) Intermediate factors include identifying the part family, standardizing the process plan, group scheduling, group tooling setup, reducing the amount of inventory that must be purchased, and using CNC machines. The work-in-process inventory, material handling, utilization of jig and fixtures set-up time, needed space, and quality are the secondary intermediate factors.
iii) Wastes in production include inventory, mobility, complexity, waiting, needless processes, and defects.
iv) goals: The major objective is to cut expenses and eliminate waste to increase productivity.

3.5 Use a simulation model.

Different scenarios for resource planning, scheduling, and investment planning can be tested and evaluated using a simulation model. The expense of finding the best solutions and the risk associated with making poor decisions in the real world can both be significantly lowered by using a virtual shipbuilding environment. (Krause, M., et.al, 2004).

Simulations procedures are:
i) Setting goals as simulations can be used for multiple goals, increasing productivity, assisting in new investments, reducing inventory, material flow analysis, manpower sizing,and continuous improvement of production.
ii) Collect the appropriate data.
iii) Build the model and establish the logic and procedures to represent the real system.
iv)Validate the form to check that the model is already working as a real system.
v) Run the simulation and collect the results, if you must, change some parameters and seehow the model behaves, otherwise, you will fall then back to step (iii).
vi) Analyze the results to aid decision-making.
vii) extract Final documentation with a detailed description of what needs to be done.

3.6 Applying Lean Manufacturing at European Shipyard (Kolich, et al.2012)

Traditional panel lines and built-up panel lines, which are still in use in many European shipyards, shall be transformed to apply lean manufacturing effectively. Combining lean concepts yields time savings and a reduction in man/hour, which immediately results in the shipyard saving a sizable sum of money. (Kolich, 2011) The classic block assembly lines seen in the majority of European shipyards are depicted in Table 1 below as being in operation.

Work station	description	Takt time (hours)	Coefficient	Takt time x coefficient = Man/hours
1	Forming a panel by joining and welding steel plates	4	4 seams x 2 workers x 4 panels = 32	128
2	The panel is turned over, and the other side is butt-welded.	4	4 panels x 2 workers = 8	32
3	Making longitudinal stiffener markings on the plate blanket	4	4 panels x 2 workers = 8	32
4	longitudinals fitting and welding.	4	4 panels x 2 workers = 8	32
5	Transportation to the built-up panel line and quality assurance.	4	4 panels x 1 workers = 4	16
6	using heat to turn and level	8	2 built-up panels x 2 workers =4	32
7	Transverse labeling, laying, and tack welding	8	2 built-up panels x 12 workers = 24	192
8	Welding of transverses.	8	2 built-up panels x 12 workers = 24	192
9	preliminary outfitting and grinding.	8	2 built-up panels x 10 workers = 20	160
10	final assembly of three-dimensional blocks before being erected on the slipway	16	11 workers	176
Total man/hours for complete block assembly				1000

Table 1 Activities of the block assembly workstations (Kolich, et al.2012)

According to the European model, the shipyard has to use lean manufacturing techniques, by applying engineering management procedures and using more new machines and robots, so, it was recommended for the shipyard under study to install the following machines in the block assembly line:

i) At lean workstation 2, install a High-grade fitting machine to do fitting up to four longitudinals simultaneously,
ii) At workstation 3, install four automatic welding machines on the girder to weld longitudinals on both sides simultaneously,
iii) At workstation 4, install three machines of one side automatic Flux-Copper Backing,
iv) at lean workstation 5, install Push-type insert equipment to push transverses,
v) at lean workstation 6, install four portable welding robots which are suspended from two girders.
The activities of the lean block assembly workstations are displayed in Table.2 below.

Work station	description	Takt time (hours)	Coefficient	Takt time x coefficient = Man/hours
1	unit plate trimming along the edges	1	5-unit plates x 4 panels x 2 workers = 40	40
2	The panel is turned over, and the other side is butt-welded.	1	5-unit plates x 4 panels x 2 workers = 40	40
3	Making longitudinal stiffener markings on the plate blanket	1	5-unit plates x 4 panels x 2 workers = 40	40
4	longitudinals fitting and welding.	1	4 one-sided seams x 4 panels x 2 workers = 32	32
5	Transportation to the built-up panel line and quality control	4	2 built-up panels x 20 workers = 40	160
6	using heat to turn and level	4	2 built-up panels x 5 workers = 10	40
7	Transverse labeling, laying, and tack welding	4	12 workers	48
Total man/hours for complete block assembly				400

Table 2 Activities of the lean block assembly workstations (Kolich, et al.2012)

4. CONCLUSIONS

The shipyard will best organize the processes if lean manufacturing is appropriately adopted. The space required by the shipyard production will be reduced, along with delivery time and consumed man/hours. Lean manufacturing and lean thinking are the keys to staying competitive in the global shipbuilding business. By using lean shipbuilding, the shipyard Block assembly line's production efficiency can be significantly increased. The best solution now available to increase production efficiency and assist shipyards, particularly small and medium-sized shipyards, is lean manufacturing. When opposed to automation, lean production is distinguished by its low cost, low investment, and significant advantages and reliance on professional workers, which is why this paper expects lean shipbuilding to be an excellent application when applied at Egyptian shipyards. In this study, a lean shipbuilding system that integrates lean manufacturing tools including just-in-time, takt time, and continuous flow operation was presented. Egyptian shipyard has the resources needed to implement lean manufacturing and fix the flaws in the conventional approach, which only focuses on plan scheduling and production process monitoring. By utilizing the lean shipbuilding methodology described in this paper, production balance may be significantly improved while staff and time waste can be significantly decreased. The current methods of shipbuilding are significantly altered by lean production, which represents the direction in which the shipbuilding industry will develop going forward. Future work will examine how lean can be implemented in the block assembly line and activity analysis in the lean shipbuilding system. also, to improve the production efficiency of shipbuilding enterprises and the market competitiveness of small and medium-sized shipyards, future work will focus on optimizing using discrete event simulation.

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MAPPING FORGING INDUSTRY MANUFACTURING OPTIMIZATION APPROACHES TO PORT OPERATIONS

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Keywords: layout optimization, manufacturing, port operations

1. ABSTRACT: The layout facility problem has been broadly studied in manufacturing as a key factor for optimizing material flow and managing the supply of material for machines. Due to the complexity of the problem, simulations are usually applied in order to analyse the performance of the proposed layout solutions and predict their efficacy. As material routing presents the main issue when observing the production line supply there are apparent similarities with port operations. In this paper we explore the option to use the simulation approach of layout optimization in manufacturing to port operations

2. INTRODUCTION

Container ports are one of the busiest logistics hubs today. Thousands of containers flow through it every day. They can be empty or full. Filled with perishable or dangerous cargo. However, they can be filled with cargo that does not require any special treatment. But handling them all has one thing in common: they take up space and consume time. This causes costs and other impacts both on the environment and on the development of the company itself. Here the question arises, are there already developed methods for resource optimization in other branches of industry and are they transferable to the maritime sector?

For a case we present optimization in a forging process and explore how to map the optimization method to provide an impact on the overall efficiency and performance of a port. A port is a complex system that involves the movement of goods, ships, and people, and it is essential that all aspects of the operation are optimized in order to minimize delays and maximize efficiency.

One of the main ways in which optimization in a forging process can impact a port is by improving the flow of goods and cargo. In a forging factory, the layout and organization of the factory is crucial in ensuring that raw materials are received, processed, and shipped out in an efficient manner. Similarly, in a port, the flow of cargo is critical to the overall performance of the port. By optimizing the flow of goods, ports can reduce delays and increase productivity.

While performance of proper production strategy has been recognized by (Acquaah, 2008) and (Khan, 2012), a vital part of manufacturing depends on proper layout. Regarding the material flow and utilization, the Facility Layout Problem has been broadly studied (A. Drira, 2007). Layouts can be measured for their efficiency (Raman, 2009), which can provide a valuable tool for planning and analysis.

Efficiency improvement has been studied by Peña-Graf et al. (2006) in which they explore the energy requirements in the iron foundry industry, where they simulate energy requirements based on production planning. With the advances of Industry 4.0, discrete event simulations have been recognised as valuable in steel industry (Gajšek et al., 2019). Jung et al. (2022) provide a discrete event simulation approach using real-time data which is implemented as a digital twin. While simulations have been widely used in manufacturing it has also been applied in port operations such as analysing developing Ro-Ro terminal development (Muravev et al., 2016).

Another way in which optimization in a forging process can inspire optimization in a port is through the use of advanced technologies and automation. Forging factories often use automated equipment, such as robotic arms, to improve efficiency and reduce errors. Similarly, ports can also use automation and advanced technologies to optimize the movement of goods and cargo. Automated cranes and other equipment can help to reduce labour costs, improve safety, and increase the overall efficiency of the port.

In addition, optimization in a forging process can also inspire improvements in the management and coordination of the port. In a forging factory, efficient communication and coordination is necessary to ensure that materials are received and processed in a timely manner. Similarly, in a port, effective communication and coordination is necessary to ensure that ships are loaded and unloaded efficiently, and that cargo is transported to its destination in a timely manner. By optimizing communication and coordination, ports can reduce delays and improve overall performance.

Finally, optimization in a forging process can also inspire improvements in the training and development of port employees. In a forging factory, regular training and professional development opportunities help to ensure that employees are up-to-date with the latest techniques and technologies, and are able to perform their jobs to the best of their abilities. Similarly, in a port, training and development opportunities can help employees to improve their skills and knowledge, and to perform their jobs more efficiently.

In conclusion, optimization in a forging process can have a significant impact on the overall efficiency and performance of a port. By improving the flow of goods, using advanced technologies and automation, optimizing communication and coordination, and investing in employee training and development, ports can reduce delays and increase productivity, just like a forging process. The experience and knowledge gained through optimizing a forging process can be used and adapted to optimize a port's operation.

On the following pages, we will present layout optimization in the company with the help of analyses and computer models. The aim of the optimization is to address a large increase in orders. Due to small-scale production, automatization is difficult and therefore layout optimization presents the only feasible approach to achieve the increased demand.

Market demands have forced the company to increase production lines, but many opportunities for improvement lie in the already existing process. With minor changes, they could raise productivity by a few percent, and they also plan to add new additional machines into their process. In this paper, we will present these minor changes and use a computer model to check how much all these investments would mean for the company.

3. METHODOLOGY

First of all, with the help of observation, we got a better picture of how the company's processes take place. Once we had a better understanding of the processes, we measured the time of one cycle for each process separately. Due to the large number of different end products, we analysed how much the average worker makes on each machine separately.

The obtained data were analysed for each production line separately in a period of 6 months. After the analysis, we made a simulation model and analysed the solutions. The role of the simulation was to evaluate available alternatives to support major strategic decisions that may involve a large financial budget.

In general, with the help of simulations, we can constantly search for a more efficient process. with their help, we can increase or decrease production volume, introduce flow improvements, shorter delivery times and better customer response times. (Miltenburg, 2008)

We will proceed with the creation of the simulation following the steps listed in the list below. The steps follow each other as listed:

1. Identification of the processes involved.
2. Network analysis and identification of material and other flows.
3. Creation of a draft simulation model.
4. Data acquisition and analysis.
5. Creation of a simulation model.
6. Running a simulation
7. Running the simulation under different conditions and for different time periods.
8. Analysis of results and development of improvement proposals.

3.1 Material flow and network identification

The material flow is conditioned by the products themselves that the company manufactures and by the production layout. Analysis of the current floor plan, which is presented in figure number 1, we found that the company has a relatively well-designed floor plan for its needs, which can be used as the basis of our model. We will be able to easily eliminate the deficiencies identified in the available space for storing material in the process and storing empty containers with simulation results.

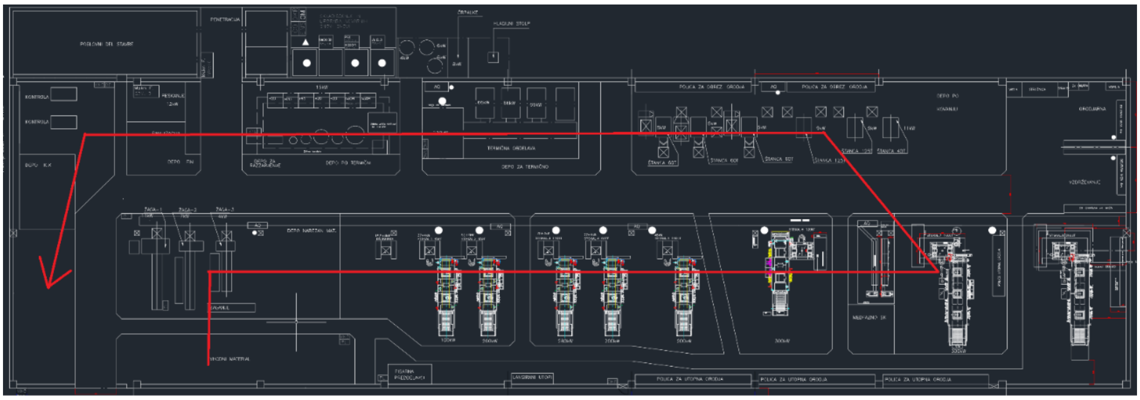

Figure 1: Current layout and material flow direction

In Figure 1, we can see that the material from the incoming warehouse to the of the finished goods warehouse travels in a "U"-shape, which in theory is a suitable shape for this type of production. The following figure (Figure 2) shows the material flow and intermediate buffer zones.

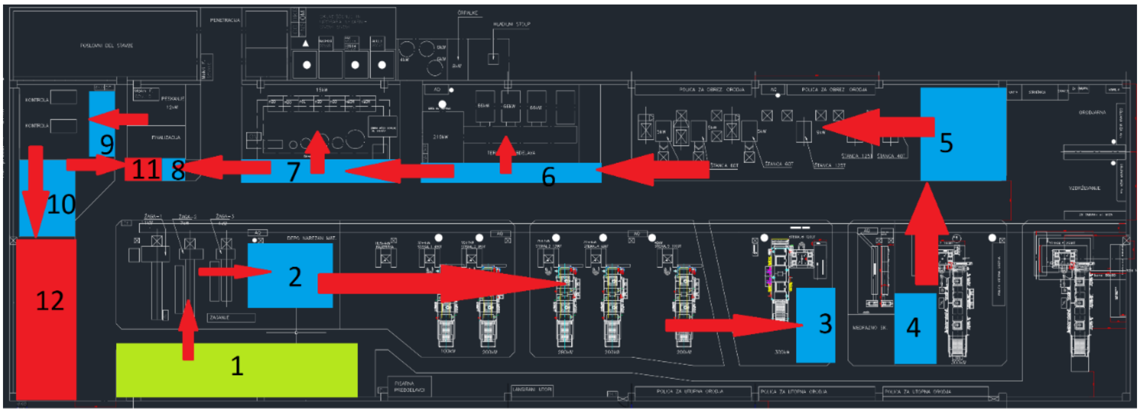

Figure 2: Material flow and buffer zones

The input material warehouse (No. 1) is marked green, from which the route continues to the first process, which consists of production on three machines. After the first process is completed, the material is stored in blue metal boxes, which continue to serve as a transport unit. All buffer zones are marked in blue. After the first stage, the boxes can be transferred to a small warehouse located between process no. 1 and process no. 2, or they can be brought to two interphase warehouses in the second process (marked with numbers 3 and 4).

From here, according to the pull system, the material goes through another process, after which the items are moved to interphase warehouse no. 5. From warehouse 5, again according to the pull system, the items are transferred to the next process, after which they are moved to warehouse no. 6, which is located before the next operation in production. The same procedure is followed for the next operation, after which the articles change boxes and continue their journey to the penultimate operation (No. 8). In the next step, the items are moved to depot no. 9 or 10, from where the final control takes the products again according to the pull system, inspects them and packs them. If the items meet the standards, they are moved to the warehouse of inspected, finished products (No. 12), otherwise they are returned to the previous operation (No. 11), where the process is repeated.

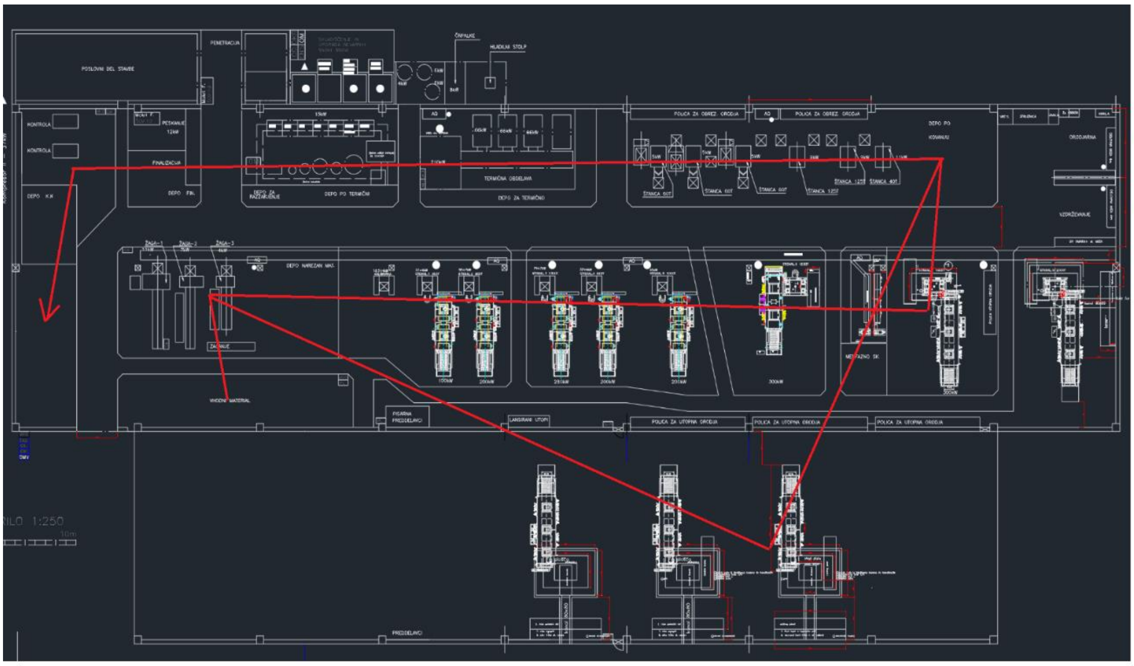

Figure 3: Proposed layout prior to simulation analysis

The future expansion of the hall needs a detailed analysis, since any deviation from the current floor plan change can be the key to the good or bad flow of the process. The original plan for the expansion of the production process is presented in Figure 3. This plan was made without detailed analysis and served only as a vague proposal to increase capacity. However, we can immediately notice the deviation from the previous flow of material, because with such a layout, we would make a lot of unnecessary movements, and on top of that, we would significantly increase the transport routes.

One would also have a lot of unused space and additional intermediate storage. It is for this reason that we later made a more detailed analysis of what layout of work machines would be the best.

3.2 Data acquisition

We obtained the data from the company's ERP system, where production is continuously recorded. We analysed the data for each machine separately where possible. For each machine or production line, we obtained monthly quantities based on how many pieces were made, and divided them by the number of working days in the month. In this way, we obtained data on the average quantity of produced pieces per machine per day for a period of six months. The average quantities per day were later divided by 1440, which represents the number of minutes in the day, giving us an exact figure of how many pieces are made per minute.

3.3 Model and simulation

This part will present the simulation model and the results obtained by observing various processes in the forging process and analysing the data obtained for each operation in the last six months. In the research itself, we made two models for simulation, where one is basic, for data comparison, and in the second model we added 3 machines, one each for the second, fourth and fifth processes. The data are presented below. The basic simulation ran for one month, and it showed that we make an average of 0.77 packets of finished goods per hour at the final production process.

Figure 4 shows all machines and their processing times. We also found that the machines in the third operation have a very small percentage of operation, but in practice they solve this by redistributing workers to other jobs, so that the efficiency is as good as possible.

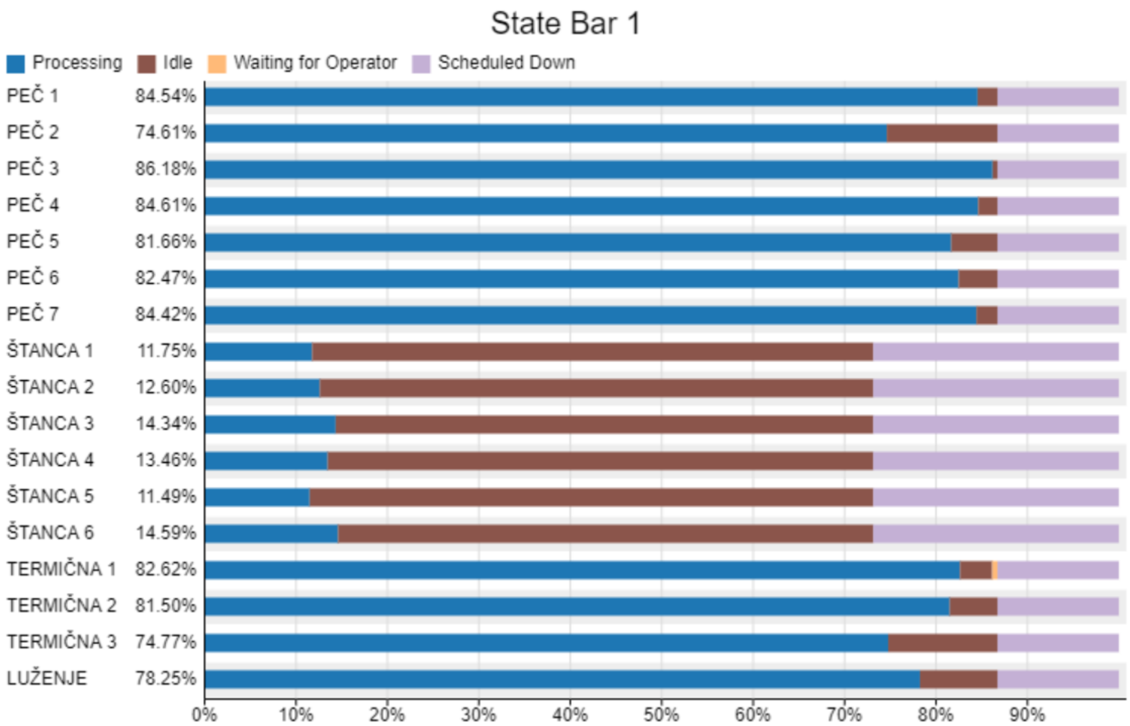

Figure 4: Utilization of production lines

Later, we added 3 machines to our model, in different operations, which we found to be bottlenecks. We found that the number of packages made every hour rises considerably. It is necessary to assume that in our simulation one package represents 400 pieces of a certain item. We did this because even in reality, items are transported in metal boxes, and the average amount of items in this box is around 400. Also, these boxes help us with the transport itself.

The number of packets made every hour rose from 0.77 to 0.95, which represents 380 pieces or 123.38%. This slightly more than 23% translates into a production of around 50,000 pieces every month.

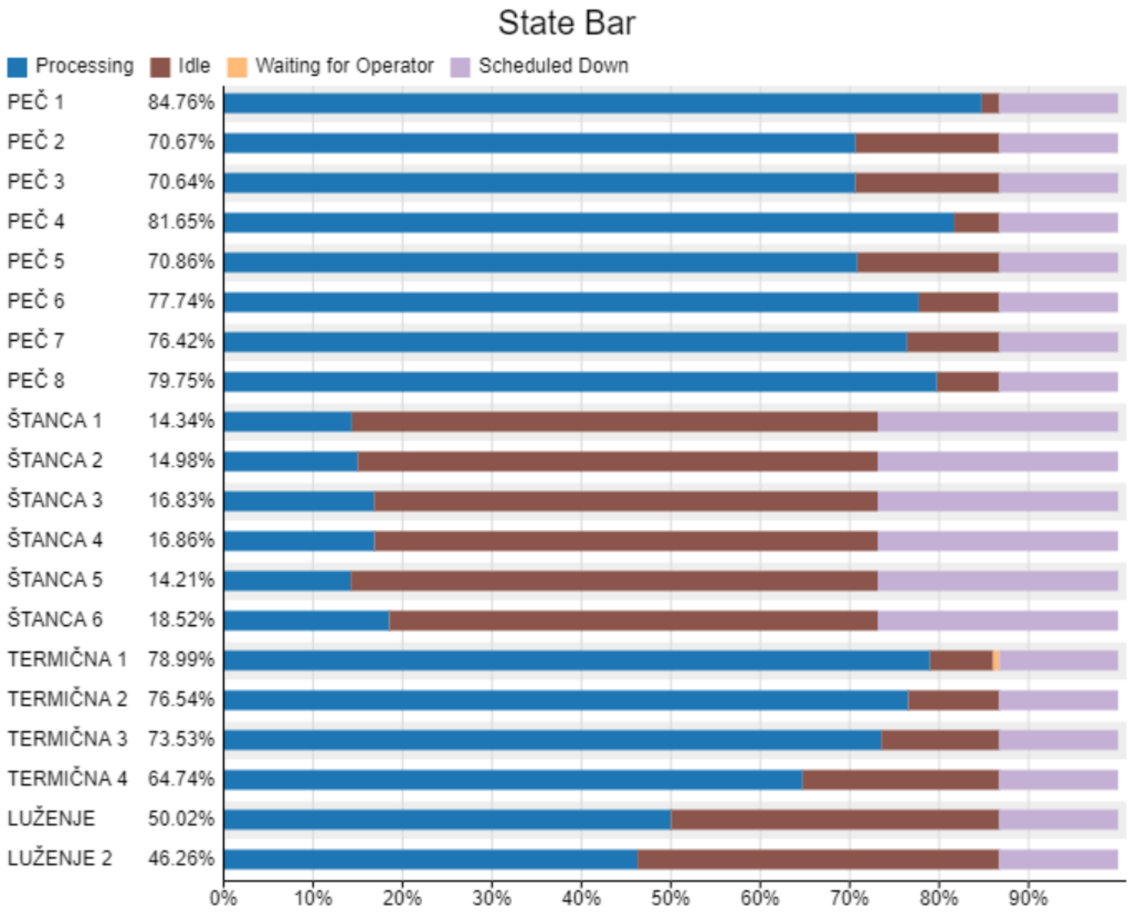

Figure 5: Production line optimization of the optimized layout

4. RESULTS

With the help of data analysis, we came to the conclusion that despite the good flow of material, the current process has a number of shortcomings, above all it has too many interphase warehouses, which consequently lead to excessive transport routes and double handling of the material. We also noticed quite a few problems when planning the new production facility.

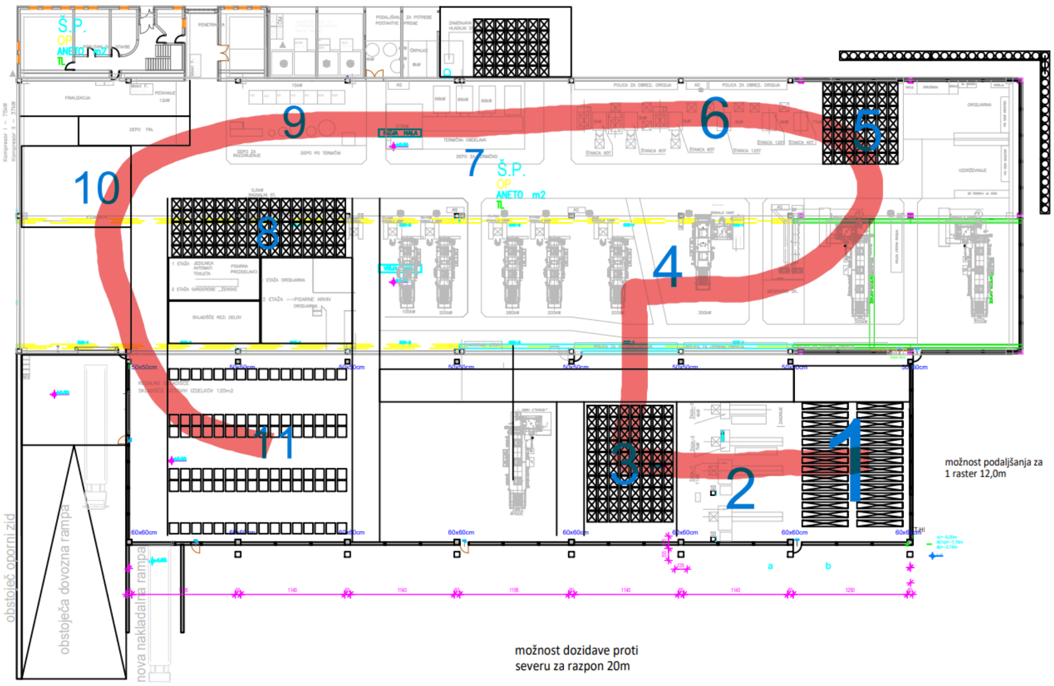

Figure 6: Proposed layout changed backed up by simulation results

The initial plan would have increased the material flow path, created additional congestion on the transport routes, and caused a deviation from the previously well-designed material flow. There would also be an increase in intermediate warehouses, in which the material sits for a considerable time and does not gain value. For this reason, with the help of analysis and simulation, we came up with a new layout of jobs. In Figure 6, we can see our proposed floor plan of the job layout. The warehouse of incoming material is moved to a new building (No. 1), where unloading will take place from the right, north side. We move the original operation (no. 2) to a new facility, because in this way they will be closer to the incoming material, and at the same time they will be able to easily stock all the lines of the second process, which are marked with the number 4 in the picture from the interphase warehouse (no. 3). From there, the crates will be moved to the intermediate warehouse (No. 5), from where the process will be the same until the last operation.

5. CONCLUSION

With the help of computer model analyses, we improved the floor plan of the distribution of tasks, which was proposed by the company, and achieved greater efficiency of the material flow through the production process. We also identified where bottlenecks occur and proposed some solutions to solve them in the future. The detailed analysis allowed us a better overview of the process itself and helped to identify places where losses occur. The model is built for production in a forging company, but is nevertheless useful for optimizing the handling of containers at the terminal. With its help, we can analyze and optimize the flow of containers through the port. This is particularly useful in cases where the development of ports is limited by space. In this way, we can save a lot of space and still increase throughput.

While port operations logistics may differ from forging processes, the main similarity presents the storage problem. While the presented case addresses the manufacturing on the production lines, it is important to observe what happens at the storage buffer zones, which can reveal bottlenecks in the production. This approach can be mapped to analyse the efficiency of other port operations that rely on any type storage and storage time. From the material flow point view port operations and forging, or basically any manufacturing industry has similar processes and which can be addressed using material flow modelling and simulation. As such cargo handling could be analysed in the same manner as production lines in manufacturing, while storage capabilities behave in a similar fashion.

Where simulation provide an actual insight into processes further advances can include machine learning approaches and real-time data capture, which can be implemented using a digital twin. As direct mapping a singular approach to another area may be difficult the idea is to focus on the basic processes and those basic characteristics, which are comparable regardless of industry type.

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RESILIENCE STRATEGIES AS A PARAMETER OF COMPETITIVENESS IN MARITIME TRANSPORT

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ABSTRACT

The focus of this study is maritime transport, with an emphasis on shipping companies and ports as the main players in the execution of marine transportation services. Since the industry is constantly facing waves and extreme volatility influenced by many factors of its internal and external environment, the aim of this work is to provide a clear insight into maritime transport players' ideology concerning the overcoming of this instability and unpredictability by establishing resilience strategies which help not only in the survival of the companies but also in enhancing of their competitiveness. Therefore, in the first stage, some groundings are set regarding the maritime industry to better understand the field. Moreover, the current market is examined through the prism of recent global events such as the Covid-19 pandemic and the War in Ukraine, which affected the global economy and, consequently, the shipping industry. The reactions of the shipping companies and the ports are described through a literature review on various resilience strategies attempting to achieve a competitive advantage in the market. The paper concludes with thoughts for further research and proposals for increasing resilience, thus, effectiveness in the shipping industry.

Keywords: Resilience, Shipping, Ports, COVID-19, Efficiency

1. INTRODUCTION

It is well known that more than 80% of international trade is carried out by sea (Michail & Melas, 2020; Sun & Zhang, 2022), as shipping is the most cost-efficient mean of transport per unit of cargo. In 2021 the total seaborne trade was about 11 billion tons (UNCTAD, 2022a). It is important to mention that sea transport services cover derived and not direct demand (Stopford, 2009). The external environment and the exogenous factors that affect shipping companies are forcing them to take measures and adopt several strategies. The environmental impact of shipping, with emphasis on sea pollution and the Green House Gas Emissions (Schermerhorn, 2010; Kavussanos & Moysiadou, 2021; Theotokas, 2018), has resulted in the development of several environmental-related regulations. Seasonality must also be considered a major element of the industry's performance. Furthermore, the internal environment of a shipping company affects its strategies, which include several players such as clients, suppliers, bankers, insurers, classification societies, executive bodies, employees, etc. (Schermerhorn, 2010; Theotokas, 2018).

Since all these factors, and many more, including those which are unpredictable such as a pandemic, an environmental disaster, a war, or a terrorist attack, have a great influence on shipping transportation, the companies need to build and constantly update their resilience strategy, becoming more flexible and always prepared for any circumstances. In general, a strategy can be examined in 3 levels: (a) the corporate strategy, which has to do with the purpose of the company and the choice of the activities to be developed (b) the competitive or business strategy, which focuses on the competitive advantage towards the competitors and (c) the functional strategy which concentration is the various functions of the company to contribute to the previously mentioned two strategy levels (Theotokas, 2018).

Having set the background, the following sections get into more detail depicting the recent events which affected the whole global economy, creating challenges and opportunities, resulting in tremendous modifications of maritime transport, and the actual shipping practices adopted by shipping companies and ports as the main actors of the sea transportation. The reflex mechanism of the market is described along with the adaptability of the organizations in practice by developing various strategies during the demanding times, followed by conclusions, recommendations for further research, and policy proposals.

2. LITERATURE REVIEW

Sea transport and ports can be affected in multiple ways with the most recent example being the covid-19 pandemic, which caused shocks and stresses in the marine sector, such as sudden changes in volume of transported goods, lack of human resources to ports and the seafarer crisis. Moreover, ports have to handle a constant changing environment, i.e., becoming carbon free and smart mobility hubs. In every tern of these transformations' new technological pathways, new business models and new human skills creating opportunities for updating and upgrading ports to the race of survival in a competitive market. At the same time, these agendas can lead in a more fragile and vulnerable sea transport and port system affecting critical functions, if not treated holistically and structured in a resilience way.

Resilience has many different concepts, and it is depending on the scientific field examined. For instance, sociology uses the term resilience to identify what makes different social networks strong throughout disaster and recovery (Aldrich and Meyer 2015), engineering identifies the resilience of built infrastructure (Bruneau et al. 2003), and economics supplies information on the resilience of local business sectors (Rose and Wei 2013). The term resilience often associated with the ability of an entity or a system to recover from a disturbance or disruption. According to McAllister (2016), the concept of resilience has evolved beyond the performance and recovery to include theories like risk-informed management, standardized assessments and mitigation methods, and technological approaches leading to an improved performance against future disasters. Therefore, the following definition is used: **Resilience** is the ability to predict, prepare for, and adapt to altering conditions and endure, respond to, and recover rapidly from disturbances while maintaining operational activities. Four key concepts in a cycle of continuous evolution can summarize this definition: prepare, resist, recover, and adapt.

Different types of infrastructures, i.e. hub or gateway port, have dissimilar vulnerabilities regarding maritime networks and its implications. Disturbances at a hub will affect greatly the maritime shipping network, while disturbances at a gateway port will mostly impact hinterland. As shipping and ports can be exposed to a variety of disruptions, it is essential for new systems to be more resilience over three core ideas:

- **Absorptive capacity** – the ability of a node or a terminal to maintain a level of its operational activities while a disruption is in progress.
- **Adaptive capacity** – the ability to route the cargo flows through alternatives nodes during a disruption so as to maintain a level of service.
- **Restorative capacity** – the ability to recover at the same or even higher level of service, in comparison with the era prior the disruption.

Shipping and port industry have to withstand and adapt to the changing environment, and to recover positively from shocks and stresses. The resilience concept is often associated with concepts like **agility, flexibility, and lean**. The term **agility** describes the time of the adaption process, making fast and unhindered changes when faced with disruptions. Immediate response, automated processes and built-in policies minimizing the adaption time leading to an agile supply chain. Such an entity utilities new technologies, methods and information systems in order to structure an organization based on constant exchange of information between different departments and a strong relationship among its customers and suppliers. **Flexibility** is the ability to use innovative solutions as an answer to a transforming environment. As far as ports considers, this attribute allows the port or the port company to alter with smoothness so as to operate under new, different, or changing requirements in a cost-effective manner. **Lean** can be described as the continuous improvement of processes that eliminating waste or non-value stops across the supply chain. A lean supply chain leads to prime financial performance for all parties involved while reducing redundancy.

2.1 The impact of recent events on maritime transport

The Covid-19 pandemic and the War in Ukraine are the most recent events that have brought a global crisis with countries still struggling to cope. The main characteristics of the present global crisis are the higher shipping cost (see Figure 1), great inflation pressure, shortages of food, higher energy price, and disturbances in the global supply chains (UNCTAD, 2022b).

During the pandemic, the international trade decreased as several countries went into continuous lockdowns. The pandemic has severely impacted the shipping industry with a decrease in freight rates in some shipping markets, which in turn damaged the cash flows of the shipping companies (Michail & Melas, 2020), along with several other operational issues related to pilotage, ports closure and problems (Sun & Zhang, 2022) and crew change processes (Iakovou et al., 2022). Especially the cruise lines faced the worst period in their history, halting operations, causing the global economy an approximate cost of 77 billion dollars until 2021 (Walters, Magor, Kelly & Wallin, 2022).

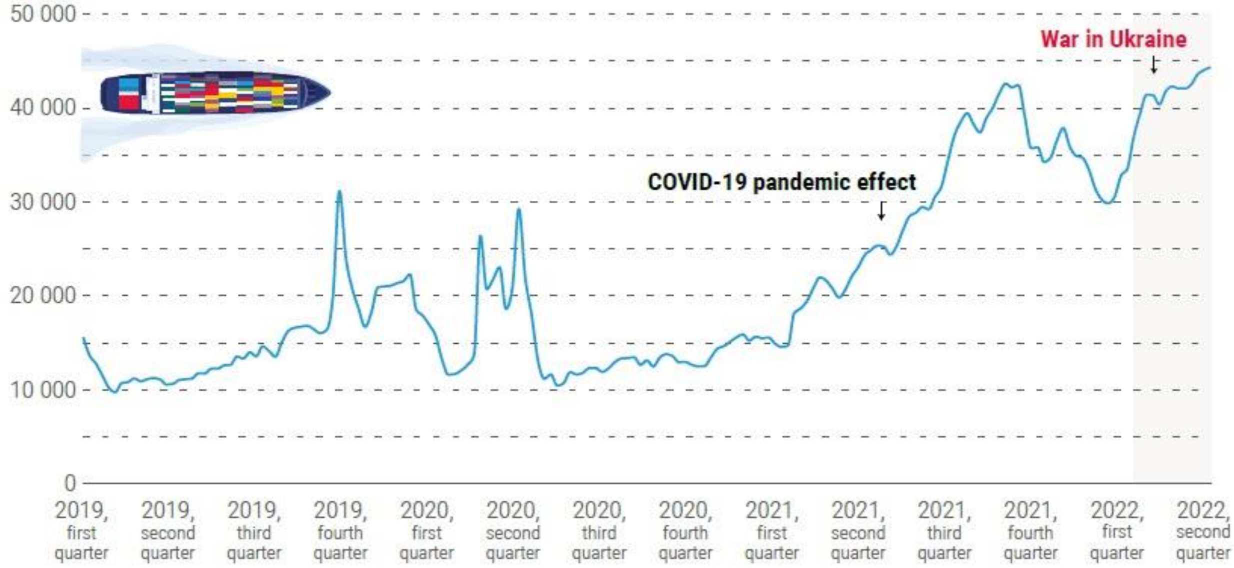

Figure 1: Clarksea Index in $/day
Source: (UNCTAD, 2022b), based on data provided by Clarksons Research Shipping Intelligence Network.
Note: The series tracks average vessel earnings across the major shipping sectors, including tankers, bulkers, containerships, and gas carriers, weighted by the number of ships in each segment.

Russia invasion in Ukraine, causing a huge impact on international trade. Ukraine is one of the most important exporters of grains, seeds, and vegetable oils, and before the war, Ukraine exported more than 90% of its agricultural products via the Black Sea. On the other hand, the Russian Federation was the leading supplier of oil and gas to Europe until recently. The war in Ukraine, however, brought sanctions and restrictions imposed by the European Union towards Russia, which led to the use of alternative shipping routes in order to facilitate the related trade. Besides food insecurity, huge problems were raised regarding energy sources, which is also one of the main factors of the global economic crisis. Consequently, the increase in energy costs led to higher bunker prices, and the vessels' calling at Ukraine's ports had a huge impact on the booming shipping cost, as shown in Figure 1. The higher transportation cost means that consumers face increasing prices eroding the purchasing power of both consumers and businesses, resulting in increasing inflation (UNCTAD, 2022c; OECD, 2022).

As regards shipping, the tanker market freight rate in the last five years faced two huge spikes, based on data from Baltic Exchange (2022). The first one started at the end of 2019 lasting until mid-2020 because of the pandemic and the emergence of Covid-19. Although the virus spread and the world's lockdown started in 2019, the oil-producing countries delayed cutting the output (Engebretsen, 2020). As a result, oil prices decreased significantly, and demand for vessels emerged to transport the oil to the shore tanks globally. When the shore tanks filled up, tankers, used as storage facilities, resulted in additional vessel shortages (Wallace & Faucon, 2020), driving the freight rates up. In 2022, another huge spike occurred due to the Russian invasion of Ukraine. European Union imposed sanctions on Russia, which resulted in a re-arrangement of shipping routes, increasing the ton-miles and, therefore, the demand for ships, especially for Aframaxes, resulting in increased freight rates. Also, given full sanctions to come, Russian oil companies provided big discounts to sell oil the soonest as possible and due to the partial suspension of Russian pipelines for supplying the EU (Capolongo, Kühl, & Skovorodov, 2022), led to excess demand of tankers.

The combination of the lockdowns, the slowing of global trade, and the oversupply of ships resulted in fierce competition in the market that pushed the freight rates to very low levels. In contrast with the tanker market, the pandemic had a negative effect on dry bulk shipping. The conflict in Ukraine also affected the trade routes and raised insurance costs for shipping companies, affecting freight rates (UNCTAD, 2022c). Overall, the dry bulk shipping market has been affected significantly by the pandemic and the war, with the freight rates mainly fluctuating on the lower levels.

Finally, in the container shipping freight market, the rapid spread of the coronavirus led to effective drop-in freight rates until 2020. The main reasons are the ports closure, crew shortage, quarantines, and other covid-19 restrictions, making the shipping companies struggle to stay profitable. From early 2020, the market started gradually to recover until 2021, with a significant increase in the freight rates. However, along with the high rates, serious problems were created in the shipping transport, as the ports faced huge congestion, with hotspots being the United States, Europe, and China (UNCTAD, 2022b). The delivery schedules were delayed a lot, and there was a shortage of equipment, workforce, and storage facilities. The situation was enhanced as the shipping companies applied Black Sailings to minimize delays. By 2022 onwards, the freight rates started to fall again. The war hampered Black Sea container lines, especially those connecting Ukraine and Russia, which resulted in delays and higher shipping costs.

3. RESILIENCE STRATEGIES

Every transaction in a shipping company must be planned with great precision and consider all the possible factors that may affect it and the objectives it seeks to achieve because the capital involved is enormous. It is widely known that the shipping market is volatile, and risk is a daily occurrence. Disruptions can be triggered from multiple sources either predictable or not. An internal disruption is related with shipping operations, such as breakage of equipment or a breach in security. The external factors are related with elements that the shipping company can't control, such as a hurricane, an economic crisis, or a pandemic. Having explained thoroughly the concept of resilience, as long as the risks that ports may face the questions that rises is "how these challenges can be dealt with?". Forecasting, Project, and Modeling tools can provide a set of actions in order to survive and thrive in the race of resilience.

- The main Forecasting tools to deal with uncertainty are the Scenario analysis and PRIMA (van Asselt, 2000) (Pluralistic Framework of Integrated uncertainty Management and risk Analysis). Scenario analysis examines different alternative futures in order to create a variety of development paths, risks, opportunities, and possibilities for policies and decision making. The most used scenario analysis methods are the scenario writing, providing qualitative scenarios, or the basic policy exercises and modeling analysis, providing quantitative scenarios. PRIMA is a tool helping in devveloping a structure focused on uncertainty management. PRIMA is the only approach that advances and provides structure to the systematic use of multiple values, paradigms, perceptions, judgments, in assessment processes.
- The main Project tools to deal with uncertainty are the SWOT analysis and Diagramming Techniques. SWOT are the initials of strengths, weaknesses, opportunities, and threats and a SWOT analysis is a familiarize process for a port or a port related organization to identify internal its strengths and weaknesses and examine external opportunities and threats. Diagramming Techniques represent graphically variables and outcomes of certain decisions or risks with the use of techniques, methods, and tools.
- Some of the most well-known Modeling tools in order to deal with uncertainty are the Sensitivity analysis, the Error propagation equations and Monde Carlo simulation. Sensitive analysis is a technique that aims to understand the quantitative sources of uncertainty and identify the sources providing the greatest uncertainty. Error propagation equations is a method aiming to assess how quantified uncertainties inserted in a propagate model produce an uncertainty range in a given model outcome of interest. Monde Carlo simulation is limited to quantified and expressed as probabilities uncertainties that aims to trace the structure of model output that results from uncertainty of model inputs.

There is a necessity to capture and quantify resilience value in a system. Tools and frameworks can be "recruited" in order to structure a shipping transformation plan and implementation that focus on shipping resilience.

3.1. Resilience strategies in ports

Across the world, ports are considered critical infrastructure. The impact of ports on the economy is critical. They serve as regional centers of employment, offering jobs to over 10-20% of the employed population in the surrounding communities; they create assets, facilities, networks, and processes. (Lengnick-Hall et al. 2011). Ports' operational and business continuity concern governments, businesses, and communities worldwide. The social and economic impact would be enormous in the case of port failure, disruption, or total shutdown. Threats to ports are implemented both by exogenous and external environmental factors and by industry actors. These threats are the trends and changes that ultimately shape world trade. (Notteboom & Haralambides, 2020). Ports must become resilient to survive environmental, geopolitical, and technological crises. A resilient port "can maintain or minimize the impact of disruptions on its logistic, industrial, and economic functions in a dynamic environment and can recover quickly from those disruptions by effectively mobilizing the resources available within its ecosystem." (Vanlaeret al., 2022)

In order to find out what resilience strategies ports must undertake in order to cope with incidents, bounce back from them, and at the same time stay competitive, we must first define what the ecosystem of a port consists of and the potential threats deriving from it. We will divide the main actors into three domains: the policy, economic, and operational domains. The policy domain of a port consists of the relationships formed between policymakers in general. Such policymakers include national and local governments, NGOs, labor organizations, media, and industry. From this specific domain, decisions and social trends, such as regulations, policies, and legitimation, influence port functions to emerge. (Dowling & Pfeffer, 1975). The economic domain of a port ecosystem describes the commercial-driven activities and the relationships between shipping companies, agencies, terminals, service providers, and competing ports. The economic domain is heavily affected by economic shocks and financial decision-making processes. (Dooms et al., 2013). The third and final domain is the operational one. All the relationships and activities required to perform basic operational activities are included here. Such activities are cargo handling, nautical Management, and the delivery of services. Incidents and accidents directly threaten this domain. (Vanlaer, Albers, Guiette, van den Oord, & Marynissen, 2022). Of course, many other factors may cause port disruption. To name a few: natural disasters like tsunamis, earthquakes, typhoons, human factors, disruption in the financial flow, ship collision, technological and organizational factors, shipping route density, labor productivity, electric power, and gas supply, etc. (Vanlaer et al. 2022).

The process of making a port resilient has three stages. The first stage is to create anticipation capabilities. That means a port must be able to observe, identify and prepare. The port authority of each port must scan the entire ecosystem of the port for any changes and then interpret those changes into threats and opportunities. (Hollnagel, 2017) For that purpose, many lead ports use international information networks to understand the future needs of their port users so they can have a long-term plan concerning their strategic port capacity planning. (Meyer, 1982) An example of using the information network is what the port of Antwerp did. During the first wave of the Covid 19 pandemic, through endless meetings and input from the Leadership Team members of the port, it was able to make strategic and tactical decisions. (van der Oord, et al., 2020) Information Management also extends to resource allocation, strengthening a port's predictive capability. (Meyer, 1982) Resource allocation planning covers the need for towage, planning of birth, locks and bridges and extends to navigational safety and port security, for example, the handling of hazardous cargo. (Bichou, 2009) Ports must also be prepared. That is ensured through business continuity management which provides a strategic framework that focuses on recovery speed. It reduces port vulnerabilities following national crisis management regulations and frameworks, incorporating them into the port authority's organization. (Herbane, Elliott, & Swartz, 2004)

The second step is the capability of a port to cope. That comes through two stages. First, the acceptance of a problem, then the development and implementation of possible solutions. (Duchek, 2020) In an unfortunate situation of disruption or change that directly affects the policy domain of a port, port authorities face an additional challenge. This is because some of the port's stakeholders may have conflicting interests. (de Langen, 2006). For this reason, port authorities need to strengthen cooperation between all stakeholders. Stakeholders must share information and be ready for possible negative effects to themselves but ultimately generally optimal solutions. (UNCTAD, 2022b) The flow of information in a port's ecosystem is crucial. In order to provide a solution to a disruptive event, first, a port must accept it, then make sense of it and finally communicate the appropriate actions. Stakeholders' cooperation is critical here as well, and that is because different stakeholders have different kinds of data regarding a disruptive situation. The role of port authorities here is vital. Through their relationship with all port actors, they can gather commercial, regulatory, and operational information and assemble them to develop a solution. (Vanlaer, et al. 2022).

The third and final step is a port's adaptive capability. That means that port authorities must improve their ability to learn from previous events and implement those lessons effectively. (Hollnagel, 2017) That can be achieved via both formal and informal incident management processes such as discussions and presentations. (Shaw, Achuthan, Sharma, & Grainger, 2019)

4. CONCLUSIONS

Shipping companies and ports follow several strategies in order to be resilient. These strategies can relate to the economic, operational, environmental, and other domains. All these aspects impact shipping companies and ports and may impose direct and indirect threats. There are several resilient strategies that can be applied to shipping companies and ports, by taking into account their peculiar characteristics in order to safeguard their operational continuity. This continuity of operation is vital and is a parameter of shipping companies and ports competitivenes. They must ensure their potential clients that they can carry out their services and be trusted. It is a fact that companies and ports with a strong brand name, which has been achieved through the successful delivery of services, are more competitive and have higher earnings. In other words, resilience strategies are a tool that shipping companies and ports use to achieve their goal, being operational under any circumstances, being competitive, and profitable.

Further research is needed on shipping companies' and ports' risk management strategies. A more in-depth study in this area could include training personnel using scenarios to manage different types of crises, as well as the policy measures taken by companies and ports. Maintaining the resilience and competitiveness of shipping companies and ports is a multifactorial equation. The adoption of a holistic approach that will encompass all factors mentioned, is needed in order to develop effective crisis prevention tactics. These would eliminate the main problem, the time lag in making critical and uncritical decisions. Research that would lead to the proposal of real-life scenario-based drills and potential risk management strategies, in addition to their theoretical value, would be highly beneficial for shipping companies and ports.

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USE OF THE GEOSPATIAL TECHNOLOGIES AND ITS IMPLICATIONS IN THE MARITIME TRANSPORT AND LOGISTICS

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Keywords: Geospatial technologies, GIS-based sensors, Maritime transport, Digital transformation, autonomous systems.

1. ABSTRACT:

All the shipping industry and also ship building (shipyards) are under a complex process of digital transformation (DT), and so are the maritime ports as part of this logistic chain of significant importance.

This paper aims to review the successive information technology (IT)-based generations that impacted the maritime transport and logistics (computer-based optimization of transport routes; use of intelligent sensors and IoT; position monitoring by using geospatial technologies and databases; intelligence-based decisions), to identify their main features, and to propose an autonomous vessel-port management system that can be implemented in the future. The role of the geographic information system (GIS) is emphasized – as GIS-based electronic route optimization that allows ships to follow new paths and deliver goods in the most economical and efficient way; GIS-based location precision with the use of on board and ashore GIS-based sensors (electro-optics, remote sensing, LiDAR).

The shipping digitalisation process is heading towards a totally autonomous and at the same time safe and reliable ship. Complete autonomy could be reached by adjoining artificial-intelligence controlled systems designed to navigate and operate the ship and that are equipped with sensing and analysis tools, situational awareness, planning, and control capabilities. The Vessel Traffic System (VTS) of the future needs innovative technologies and methodologies to be developed. The desired systems will automatically collect and process data with high precision, will provide input to decision-making systems, and suggest evasive maneuver; to deal with hazards and systems failure without human intervention onboard. The use of new technologies comes with new types of risks specific to maritime transportation and seaports (spoofing, data manipulation, cyber-attacks etc.)

The implications of the findings are important for all stakeholders involved in maritime transport and associated logistics (seaports).

2. INTRODUCTION

Maritime transportation of goods is an essential part of global trade and commerce. It enables the efficient, cost-effective movement of large quantities of goods over long distances. It is also a critical component of global supply chains, providing a low-cost alternative to air transport and ground transportation for many goods. Maritime transport is also important for the transportation of energy resources such as oil and gas, as well as for providing food security and connecting isolated communities. Maritime transportation is by far the most used method of goods transportation today, comprising about 80% of all merchandise transport volume [1]. By playing such a key role in the world's economy, it has been the main focus of many scientists and engineers research on how transportation methods and means can be improved, in order to gain efficiency and security.

The digitalization of the shipping industry is transforming the maritime transport and logistics sector at an unprecedented pace. In this paper, the successive information technology (IT)-based generations that have impacted the industry are reviewed in order to identify their main features and to anticipate what the future could hold. The role of the geographic information system (GIS) is emphasized, as well as the importance of developing innovative technologies and methodologies to achieve complete autonomy. The research objective of this paper is to investigate the impact of digitalization on the shipping industry, with a focus on the role of geospatial technologies in this process. The main research question is: what are the geospatial technologies suitable to be implemented in a fully autonomous system for cargo ships operations? The implications of the findings are discussed with regards to hazards and risks specific to maritime transportation and seaports. This paper aims to provide essential insight into the digital transformation of the shipping industry, and to inform all stakeholders involved in maritime transport and associated logistics.

3. LITERATURE REVIEW

The successive generations of information technology that have impacted the maritime transport and logistics industry include:

- Computer-based optimization of transport routes: This refers to the use of computer algorithms and software to optimize the route and schedule of a vessel, taking into account factors such as cargo volume, weight, destination, and vessel capabilities. This can help reduce fuel consumption and improve efficiency [2].
- Use of intelligent sensors and the Internet of Things (IoT): Sensors and IoT devices can be used to monitor various aspects of a vessel's operation, including cargo temperature, fuel consumption, and engine performance. This data can be used to improve the efficiency of the vessel and reduce costs [2,3].
- Position monitoring using geospatial technologies and databases: Geospatial technologies such as GPS and GIS can be used to track the location and movement of vessels in real-time, allowing for better visibility and coordination within the supply chain [4].
- Intelligence-based decisions: Machine learning and artificial intelligence can be used to analyze large amounts of data and make intelligent decisions based on that data. This can include things like optimizing vessel routes, predicting maintenance needs, and identifying opportunities for cost savings [3].

These four directions combined lead to the vessel of the future: an autonomous surface vessel (defined in different papers as autonomous surface vessels, autonomous surface vehicles, maritime autonomous surface ships, uncrewed surface vessels, unmanned surface vessels etc.). Autonomous surface vessels (ASVs) are self-navigating boats or ships that are able to operate without human intervention. Starting from the 2010s, the main focus in maritime industry research papers was comprised of ASVs and unmanned systems. The majority of efforts in these papers are centered on creating more dependable algorithms for autonomous navigation, guidance, and control [5, 6]. By utilizing these algorithms, the human operator's mistakes can be minimized, leading to increased energy efficiency, safety, and cost-effectiveness in waterborne transportation [7]. In 2019, the Maritime Safety Committee (MSC) [8] – a board of the International Maritime Organization (IMO) that deals with all matters related to maritime safety and maritime security which fall within the scope of IMO, has adopted the "framework for the regulatory scoping exercise for the use of maritime autonomous surface ships (MASS)" (Annex 2) [9]. MSC defines four degrees of autonomy organized as follows:

" Degree one: ***Ship with automated processes and decision support***: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

Degree two: ***Remotely controlled ship with seafarers on board:*** The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

Degree three: ***Remotely controlled ship without seafarers on board:*** *The* ship is controlled and operated from another location. There are no seafarers on board.

Degree four: ***Fully autonomous ship:*** The operating system of the ship is able to make decisions and determine actions by itself." [9]

Literature on autonomous vessels presents various type of prototypes with various degrees of autonomy (older prototypes tend to be less autonomous and newer prototypes tend to be fully autonomous) [10-16]. One study [17] reviews many prototypes and projects developed by scholars or private companies (60 prototypes of unmanned vessels are listed and classified by the degree of autonomy). It is noteworthy that the number of autonomous vessel projects and prototypes has increased over the years, with a particularly high concentration of low-level autonomy projects due to their potential for immediate adoption by the industry. The authors present the findings of their experimental study on a nonlinear control logic for autonomous ship maneuvering in [18-20]. In [21], a new autonomous surface unit is designed that can be configured as either a large unit or a fleet of smaller units capable of autonomously transporting a single container [22]. This unit has the potential to significantly impact the shipping industry in a short period of time.

One aspect that is very important for ASVs is the communication infrastructure to deal with all the links between system components (sensors, neural networks and vessel operators). The authors in reference [23] discuss the various Information and Communication Technologies (ICT), communication architectures, and wireless standards that are being considered for the use in autonomous surface vehicles (ASVs). One of these technologies is the Internet of Things (IoT), which is seen as a promising solution for efficient communication management on ships. The authors in reference [24] also highlight the potential of IoT in this context. Although IoT technologies have advanced enough to be used in unmanned navigation systems, these systems also require the support of intelligent algorithms and methods, as well as a platform for managing and coordinating the interactions with these algorithms and dynamically selecting the appropriate level of automation for the ship.

Computing infrastructures are an essential component of ASVs as they provide the necessary computing power and resources to support the various tasks and operations of the ASV. These tasks can include navigation, mapping, data processing, communication, and decision-making. The computing infrastructure of an ASV typically consists of one or more processors, storage devices, and networking equipment [25, 26]. The processor(s) are responsible for executing instructions and performing calculations, while the storage devices are used to store data and programs. The networking equipment is used to connect the ASV to other devices and networks, such as satellite or cellular networks, and to enable communication with other ASVs or control centers [27, 28].

The computing infrastructure of an ASV can be designed in a variety of ways, depending on the specific requirements and constraints of the ASV's mission and operating environment. For example, the ASV may need to have a robust and reliable computing infrastructure to ensure that it can operate continuously for extended periods of time, even in challenging conditions. Alternatively, the ASV may need to have a lightweight and compact computing infrastructure to minimize its size and weight [29], [30].

In the context of ASVs, geospatial technologies can be used to navigate and position the ASV, as well as to map and monitor the surrounding environment. For example, geospatial technologies such as GNSS and GIS can be used to accurately determine the ASV's location, orientation, and movement, as well as to generate maps of the surrounding area [31-33]. These maps can be used to identify potential hazards or to plan the ASV's route. Geospatial technologies can also be used to monitor the environment around the ASV, such as the ocean conditions, weather patterns, and the presence of other vessels. This information can be used to improve the safety and efficiency of the ASV's operations [34-36]. Although the aforementioned papers take in consideration geospatial technologies to be used in ASVs building, there is a gap in the study of the emergent sensors implementation on the future vessel system.

In the development of the next generation of autonomous surface vehicles (ASVs), the incorporation of Artificial Intelligence (AI) and augmented reality (AR) is vital to be used to create reliable, efficient, and comfortable ASVs [37]. When these technologies are combined, they can support the user in performing complex and challenging tasks. Reference [38] presents a decision support system with an AR visualization system as an example of how these technologies can be used in this context.

4. PROPOSED SOLUTION TO OBTAIN FULL AUTONOMY IN TRANSPORT AND PORT OPERATIONS FOR CARGO SHIPS

There are more options to control the traffic near ports and terminals in an autonomous way, and one of them is to have an Ashore Operations Center (AOC) that ensures near shore vessel routes management, either by planning routes in the internal system and sending them to the navigation systems of ASVs to be implemented, or receiving them from the ASVs navigation system and validating or correcting them to ensure safe navigation. For large ports, networked AOCs can handle traffic by sectors, with the ability to hand-over-take-over routes management when a vessel (either autonomous or manned) passes from one sector to another. We can distinguish the following parts for a fully autonomous port and traffic management system: AOC, ships (either manned or ASV), sensors (on-board and ashore), AI/ML neural networks (see Figure 1). One key component in this proposed system are the sensors, as they provide information on location of the ship and environment surrounding the ship. The system can be implemented for a heterogeneous mix of autonomous and manned ships (the major change for interacting with manned ships will be given by the data exchange amounts and type and by the implementing method of the recommended route). Interconnected AI neural networks (ANN), will be used to process data from sensors, develop navigation routes, enable risk management and evasive maneuvers and implement commands to operate the ship on a determined optimized route.

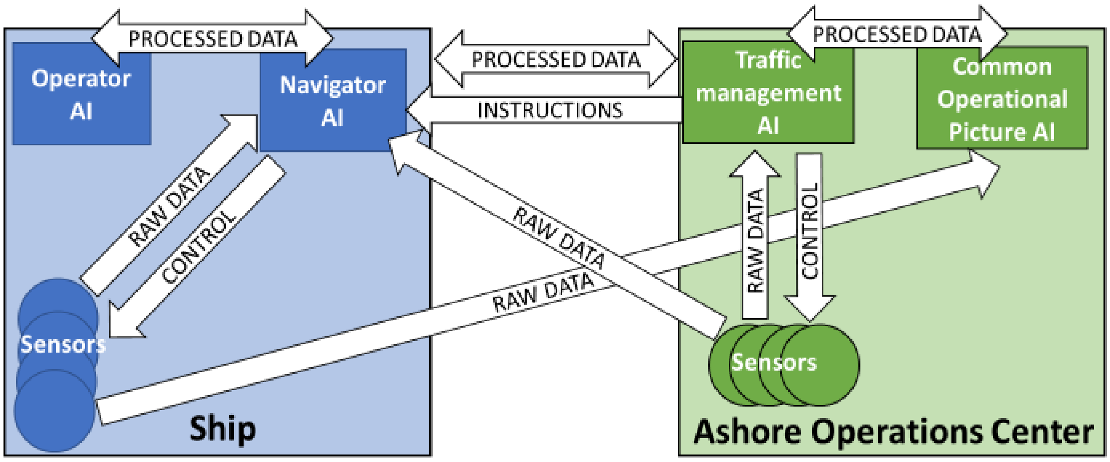

Figure 1: Autonomous port and traffic management system components and interactions.

4.1 Sensors

Sensors in the system will consist of two entities, one controlled by the ship and being positioned onboard and one controlled by the AOC and positioned on land (or sea), air or/and space, near the AOC area of responsibility. Onboard sensors can be classified in two categories: mandatory or permanent sensors, such as GPS sensors, and enhancing, or task specific sensors, used to accurately determine the environment surrounding the ship in specific tasks, such as docking operations.

The main requirements for the onboard sensor are: to be reliable and accurate, to be energy efficient, to be cost effective. In the authors view, the permanent sensors and tracking systems should consist of: GNSS [39], AIS [40], Sonar [41], EO, IR or LiDAR [42] sensors from the geospatial sphere used to compose the gross picture of the surrounding environment for the ship, in order to avoid collision. Other sensors, such as inertial, velocity and acceleration measurement sensors should be integrated too. Task specific sensor requirements are: accuracy and timeliness. These sensors are to be used to accurately determine surrounding objects detected by permanent sensors in order to provide accurate, on time data for the navigation AI system, for it to generate evasive maneuver routes or to establish the optimal route during docking operations or near port operations, in heavy traffic conditions. A mixture of sensors encompassing technologies such as Sonar, IR and LiDAR should be used, that will guarantee accurate detection of surrounding objects and sea bottom, with little or no influence from weather or visibility conditions. Another set of task specific sensors are the one measuring and monitoring internal systems of the ship used for propulsion and maneuver.

The main requirements for the ashore sensors are: to be reliable and accurate. One of the most suitable technology for this task, in the view of the authors, is Synthetic Aperture Radar (SAR) [43] technology, because of its properties to create high resolution images, regardless of visibility conditions, and is not obturated by clouds or smoke. A network of sensors based on land, sea, air or space is desirable to ensure redundancy and desired accuracy for AOC.

4.2 AI neural networks

The proposed architecture of the ANN is based on the principle "many to many" recurrent neural network [44]. This recurrent network will encompass at a minimum the following elements: ship AI (navigation, operation, sensors control) and ashore operations center AI (traffic management, ship control, sensors control, common operational picture). The ANN recurrence is needed to connect the outputs of all neurons to inputs of all neurons and to provide feedback between hidden layers. The proposed hardware implementation is based on Field-Programable Gate Array boards (FPGA), as it offers more robust computation parallelism and low latency needed for time sensitive signals from sensors [45-48]. Figure 2 depicts the proposed architecture for the recurrent neural network to be implemented in the system. CPUs or GPUs hardware solutions are also possible with the proposed architecture with the specified properties. The entire network should be regarded as a network of networks or a system of systems.

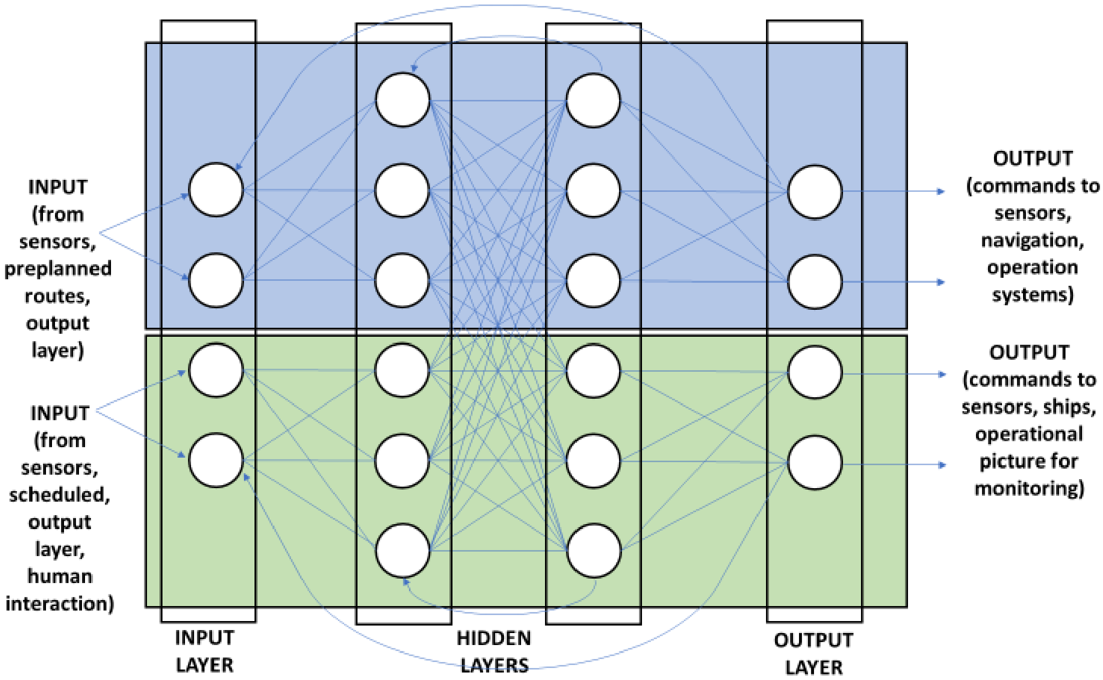

Figure 2: Proposed architecture for the recurrent neural network.

4.3 Working scenarios

The working scenarios that arise in the near future and on long term are as follows: fully automated ships in fully automated ports, fully automated ships in semi-automated or non-automated ports, semi-automated ships or manned ships in fully automated ports and the last case, semi-automated or manned ships in non-automated (manned) ports. In Table 1 is presented a comparison for these four working scenarios, starting from the right column (current state) and progressing to the left towards the end state. As this should be a progressive change, standards need to be adopted as early as possible to ensure interoperability and standardization across the entire field.

Table 1. Comparison between different working scenarios

ASV/AOC	*ASV/ Manned port*	*Manned Ship/Automated port*	*Manned ship/Manned port*
Fully automate system	Autonomous ship in independent mode	Automated routing, manually navigated by ship	Non automated traffic
Supervision may be emplaced	Port manned work required	Ship manned work required	Manual actions mandatory on both sides
Final state	Interim	Interim	Current state

5. CYBERSECURITY CONCERNS

Autonomous surface vessels are becoming increasingly prevalent in various industries, including shipping, oil and gas, and defense. These vessels rely on advanced technology, including sensors, navigation systems, and communication systems, to operate without a human crew on board. While the use of ASVs can bring significant benefits, such as cost savings and increased efficiency, it also introduces new cybersecurity risks that must be carefully managed.

One major risk to ASVs is the potential for cyberattacks on their systems. These attacks could be carried out by hackers or other malicious actors who seek to gain control of the vessel or disrupt its operation. For example, an attacker could manipulate the ASV's navigation system to alter its course or speed, or could interfere with its communication systems to prevent the vessel from communicating with its operators. These types of attacks could have serious consequences, including damage to the vessel and its cargo, injury or death to people in the vicinity, and environmental harm.

To mitigate these risks, it is essential that ASVs are designed and operated with strong cybersecurity measures in place. This can include using secure communication protocols, implementing robust authentication and access controls, and regularly updating and patching software to fix vulnerabilities. It is also important to have backup systems in place to ensure that the ASV can continue to operate safely in the event of a cyberattack or other system failure [49].

In addition to protecting the ASV itself, it is also important to consider the cybersecurity of the broader ecosystem in which the ASV operates. This includes the communication systems used to remotely operate and monitor the vessel, as well as any other systems or devices that may interact with the ASV. Ensuring the security of these systems is critical to preventing attacks that could compromise the ASV [50].

Overall, the use of ASVs brings numerous benefits, but also introduces new cybersecurity risks that must be carefully managed. By implementing strong cybersecurity measures and regularly testing and updating these measures, ASV operators can ensure the safe and reliable operation of their vessels.

6. MANAGERIAL IMPLICATIONS AND RECOMMENDATIONS

The proposed system for autonomous surface vessels has the potential to improve the maritime industry by introducing the concept of dynamic cooperation. It aims to improve existing technology through the use of augmented and virtual reality, machine learning, and artificial intelligence algorithms to provide reliable control of autonomous ships in various navigation scenarios. To effectively extract and clearly represent information, the system will need to be tailored specifically to the maritime context and its challenging environmental conditions while meeting strict safety requirements.

Adopting an autonomous traffic management system the authorities can have several potential benefits including: increased efficiency (fast navigation through ports will reduce the time required for loading and unloading cargo and will minimize delays); improved safety (an autonomous system can reduce the risk of accidents and collisions by providing real time information about the ship's surroundings and automatically adjust the course of the ship or provide evasive maneuvers solutions; the human error risk is also eliminated); reduced costs (an autonomous system can reduce the costs associated with operating ships in ports, such as personnel costs or fuel costs); lower environmental impact (the environmental impact of shipping can be reduced by choosing optimized routes and reducing the amount of time spent in ports).

7. CONCLUSIONS

This system is a unique innovation that does not yet exist in scientific literature or industrial projects, as far as the authors know, and it has the potential to be a game-changer in the maritime industry as it enables ships with different control strategies developed by different automation providers to navigate together with crewed ships. In addition, the use of automatic technologies that support service management can help to rationalize assets and improve the efficiency and environmental sustainability of the industry, while also providing support to workers by predicting hazardous and stressful conditions. By enabling automated interactions among multiple entities, this system can also facilitate the adoption of autonomous ships and simplify the interactions between diverse systems while ensuring optimal performance.

The novelty of this study consists of the proposed architecture for future shipping operations, the proposed model for recurrent neural network to achieve the IoT workflow needed in the system, and the use of FPGA as hardware support for this task.

One key part of the entire system is the proper implementation of sensors that are able to guarantee continuous surveillance and situational awareness, without being perturbed by weather conditions or other visibility disturbing factors.

The proposed software and hardware solution to implement the system brings clear benefits, as shown in section 4.2. Further studies could take in consideration building a model, at first in an enclosed environment, that can be later optimized. One potential approach to implementing the proposed system is to build a model using software such as Python and the TensorFlow library, and then optimize the model for use on FPGA. This approach has several potential benefits.

First, building a model in an enclosed environment, such as a simulated port, can allow for more controlled testing and development of the autonomous system. This can help to identify and address any potential issues or challenges before the solution is deployed in a real-world setting.

Second, optimizing the model for use on an FPGA can help to improve the performance and efficiency of the ASVs and AOCs. FPGAs are specialized devices that can be programmed to perform specific tasks, such as image processing or navigation, more efficiently than general-purpose processors. Using an FPGA to run the proposed model can help to reduce the computational resources required, which can be especially important in a resource-constrained environment such as a ship.

8. CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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Modern Risk Management Strategies

Arab Academy for Science, Technology, and Maritime Transport

The International Maritime and Logistics Conference "**Marlog 12**"
Innovative Technologies for Ports and Logistics
Towards a Sustainable Resilient Future"
12 – 14 March 2023

DIGITAL TWIN-BASED UNMANNED AIR TRAFFIC MANAGEMENT FOR EMERGENCY RESPONSE

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Keywords: UAV, flight regulations, Air traffic management, digital twin

1. ABSTRACT: The use of drones or UAVs for commercial and civilian purposes has grown steadily in the last years, however the legislature governing their use is very slow to adapt to the new possibilities that the developing technology delivers. The existing regulations are mostly based on commercial flight regulations and do not encompass the whole spectrum that the UAV solutions can provide. While each country follows their own regulations, most are still restrictive for a broader use of UAVs. The use of UAVs for emergency uses, surveillance, and monitoring has been broadly studied. As such UAVs can be used to transport human organs or medical supplies, detect forest fires, monitor flooding, provide or extend communication range in case of outages, etc. The current regulations in most countries with their restrictions currently do not provide a viable solution to fully employ this UAV capabilities without a lot of administrative work. As the use of drones can pose a hazard for the population as well as the environment, solid regulations are necessary to minimize any risk, however too strict regulations can prevent an efficient use of drones. Changing the regulations to provide a broader use of drones would only increase the risks without addressing the main issues. A digital platform for unmanned aerial traffic management proposed in this paper addresses these issues directly and provides grounds for the changing of the regulations to allow a broader use of drones. Designing the platform as a digital twin of the aerial surveillance process allow for detailed overview that not only observes the currently active UAV data but can predict potential hazards and act accordingly to prevent them or minimize their effects, this increasing overall safety of UAVs, the environment, and general populace.

2. INTRODUCTION

Drones or unmanned aerial vehicles (UAV), are an unmanned aircrafts guided by remote control or on-board computers. The wingspan of unmanned aerial vehicles can be up to 61 meters and there weigh up to 15,000 kilograms. They can be used for commercial, military, and home-use purposes. We can classify them into three main areas of application: civilian, environmental, and defence (Macrina et. al, 2020). The number of drones is increasing and according to the Federal Aviation Administration (FAA) on October 27, 2020 there were 1,726,726 drones registered in the United States alone (FAA, 2020). The demand for drones is increasing, as is their development and use versatility.

Contemporary research confirms that along with classical commercial use, the drones are increasingly more employed in emergency situations where they can provide either necessary equipment or surveillance capabilities.

That there is still a lot of place for development here is shown in the study by Zailani et al. (2020), which notes a significant deficiency in the number of reported studies analysing mode of medical product transportation and adaptation of drones in maternal healthcare. They suggest that a future drone research framework should focus on maternal healthcare-specific drone applications in order to reap benefits in this area. Korent, Smereka, and Szarpak (2019) believe that the use of drones for medical purposes brings many advantages, such as quick help, shortening the time of traveling to the patient, reduction of complications in the injured owing to a short time to wait for rescue, support and improvement of basic operations of medical emergency teams, and the opportunity to reach places inaccessible for basic means of medical transport (e.g., because of floods and blocked roads). One of the areas where drones are and will be very useful are emergency situations for the delivery of automated external defibrillators (AEDs).

Seding et al. (2020) in their research came to the conclusion that drone-delivered AEDs may be feasible and effective but successful uptake in smaller communities will require a deep understanding of a community's cardiac arrest literacy levels, information needs, and readiness for innovation. They believe that this work will inform a robust community engagement plan that will be scalable to other locations considering a drone AED program. Cheskes et al. (2020) and Zègre-Hemsey et al. (2018), furthermore believe that AED drone delivery is feasible, with improvements in response times during simulated out of hospital cardiac arrest scenarios. Their opinion is that AED drone delivery has the potential to decrease the time to defibrillation in rural and remote communities. Further research is required to optimize the integration of drones into the emergency response system, as well as improve strategies to simplify bystander application of a drone-delivered AED. Mermiri, Mavrovounis and Pantazopoulos (2020) found out that while drones have the potential to dramatically improve cardiac arrest patient care, further studies are needed to evaluate their effectiveness in real-life clinical scenarios. Yakushiji et al. (2020) in their study examined UAV-assisted transportation in Japan, a natural disaster hotspot, with a focus on the potential uses of UAVs in situations where traffic blockages make ground transportation impossible. Their conclusion is that UAVs can be used during disasters, especially when traffic is blocked in both urban and suburban areas, in affected areas where people's survival is threatened by medicine and medical supply shortages, and in areas where there is a need to secure food after the disaster. A drone that is equipped with a portable AED can fly from a base station to the patient's site where a bystander receives it and starts treatment. In paper written by Wankmüller et al. (2020) were considered such a response system and proposes an integer linear program to determine the optimal allocation of drone base stations in a given geographical region. In detail, the developed model follows the objectives to minimize the number of used drones and to minimize the average travel times of defibrillator drones responding to sudden cardiac arrest patients. In an example of application, under consideration of historical helicopter response times, the authors have tested the developed model and demonstrate the capability of drones to speed up the delivery of AEDs to sudden cardiac arrest patients. Results indicated that time spans between sudden cardiac arrest and early defibrillation can be reduced by the optimal allocation of drone base stations in a given geographical region, thus increasing the survival rate of sudden cardiac arrest patients.

While providing necessary equipment in timely fashion can be one of critical uses of drones in emergency situations, other most commonly used are for providing monitoring capabilities in disastrous events to provide critical information to responders. As such valuable data can assist firefighters through fire monitoring. Sudhakar et. al (2020) research the possibilities of image analysis for detection of fire forests. The drones are used to provide a quick overview of affected areas, while the visual inspection is not their main but instead analyse the images for smoke detection and evaluate them for fire potential. Lindner et. al (2015) researched capabilities of UAVs for landslide monitoring and found that measurements taken by the UAVs provide a cost as well as time-effective way to gather data and allow their further analysis. While immediate emergencies, proper monitoring at regular intervals can trigger alerts and allow to manage such events on time. Along with monitoring UAVs have proven to be a useful tool for search and rescue missions in less accessible areas where fully autonomous UAVs can be employed in search and rescue operation and avalanche events.

Numerous uses of UAV to ensure increase security and provide support in emergency situations exist today, however the governing legislative does not provide full support to employ the full potential of drones. With an increased use of UAVs in the future the requirement of a comprehensive overview system is a necessity. With an ever-increasing traffic and various events that take place in the urban environment the overview of all critical occurrences is a necessity to ensure the safety for all participants. In this regard, much of recent research has been focused on digital twins.

While the origin of the digital twin concept can be found in manufacturing it has since been applied in various areas. A digital twin is a digital representation of a physical product, process, or service as described by Qi et. Al (2019). This representation is based on real-time data acquired by sensors as well as on historical data that can be used to improve the digital model of the physical world. Although there are different views as to what a digital twin is (Schleich et. al (2017), most of the interpretations describe it as an advanced simulation and optimization approach that does not focus solely on modelling a single product or process but can work as a merger of combination of different simulation models. Although digital twins may be mostly researched in manufacturing and product life cycle modelling, the approach has proven to be useful for simulation of any of more complex systems.

Digital twins indicate great opportunities for modelling and managing the processes in cities, supporting the transformation to Smart cities (Farsi et. al, 2020). As a Smart city's functioning is based on collecting and processing data, this may be limited to subsystems governing specific areas such as traffic and transportation, energy management, healthcare, security etc. While each of the subsystems could be modelled by digital twins to provide individual modelling of the said areas, however by linking information provided by sensors to be used by all participants can provide an all-inclusive overview and yield opportunities to optimize the quality of life and increase overall safety.

An increase in UAV use in an urban area will increase potential hazards to property, environment or population. Similarly, as regular traffic can be governed by an information system and incorporated into the Smart city digital twin, the same concept can be arranged for air traffic control. A systematic overview of the UAV activity in urban is necessary in order to ensure safety and avoid accidents or at least minimize their consequences. As such a complete unmanned air traffic management system (UATM) that is incorporated into a digital twin of a Smart city can provide the solution to the presented problem. By accessing the collective data of all Smart city parties, the digital twin can detect or even anticipate increase in traffic, gathering of people, emergency situations, and other events, and react according to them.

According to this the UATM system should not only provide surveillance of the airways and UAV activity, but must also incorporate any crucial events provided by the Smart city digital twin. As a participant the system must also provide the data to the twin for instance by informing proper authorities about accidents or other events to guarantee timely action. The application of drones in Smart cities has been researched by Mohammed et. al (2014), where opportunities included remote surveying, surveillance for security purpose, traffic management, disaster control and monitoring among others.

Either incorporated into a Smart city solution or an autonomous UATM system implemented properly is necessary to ensure safety, which one of main reasons for the slow progress of regulations covering unmanned flight. A solid technological solution that prevents accidents and enables a rapid warning system support would set the foundation for changing the regulation in order to provide new opportunities. As such Yun et. al (2022). propose reinforce learning for managing multiple drones for surveillance purposes.

While much research is done in this area, there appear to be diverse approaches that ignore the regulative branch of the problem. This paper explores a solution that follows the European U-space framework guidelines and thus adheres to the regulations while providing advanced features to ensure automation on a higher level.

3. UAV REGULATION OVERVIEW

The lack of regulations hinders the use of UAVs for emergency as well as commercial use. While the past restrictions applied to the use UAVs have been the result of slow legislative development, the direct result this is slow progress in the commercial and civilian use of UAVs. As such it depends on local regulations of each country to set the requirements. Providing a complete set of regulations for can ensure a safe and responsible use of UAVs that allows new business opportunities as well as increase safety by providing new approaches such as transporting medical supplies or monitor hazardous conditions.

3.1 EU Regulations

In Europe, drone regulations are handled by the European Union Aviation Safety Agency (EASA). EASA is the centrepiece of the European Union's strategy for aviation safety. They ensure that flights are safe in all phases: beginning with the rules the airlines and crew need to follow through to the certification of the aircraft. The latest European regulation dictate drone users will be legally obliged to register as users of their drones with their national aviation authorities from December 31, 2020, when the European regulation on drones (EU) 2019/947 takes effect. Most important EU Regulations for operations in open and specific category are Commission Delegated Regulation (EU) 2019/945 and Commission Implementing Regulation (EU) 2019/947. First one is about technical requirements and third country operations, entered into force and became applicable on 1st July 2019. The second one is operational requirements and registration which also entered into force on 1st July 2019 and became applicable on 1st July 2020. Some of those most important regulations for all kind of drones' category define that the during flight, the unmanned aircraft is maintained within 120 metres from the closest point of the surface of the earth, except when overflying an obstacle, the remote pilot ensures that the unmanned aircraft is kept at a safe distance from people and that it is not flown over assemblies of people. The maximum take-off mass of unmanned aircraft has a less than 25 kg. During flight is for the unmanned aircraft prohibit carry dangerous goods and drop any material. Operations in subcategory A1 must comply with the conditions carried out in such a way that a remote pilot of the unmanned aircraft does not overfly assemblies of people and reasonably expects that no uninvolved person will be overflown. In the event of unexpected overflight of uninvolved persons, the remote pilot shall reduce as much as possible the time during which the unmanned aircraft overflies those persons in some cases flying over people also is not allowed. For subcategory A2 applies if the unmanned aircraft does not overfly uninvolved persons and the UAS operations take place at a safe horizontal distance of at least 30 metres from them; the remote pilot may reduce the horizontal safety distance down to a minimum of 5 metres from uninvolved persons when operating an unmanned aircraft with an active low speed mode function and after evaluation of the situation regarding: weather conditions, performance of the unmanned aircraft and segregation of the overflown area. For some category applies that safety distance is keeping a minimum horizontal distance of 50 meters from people. Operations in subcategory A3 shall be carried out at a safe horizontal distance of at least 150 meters from residential, commercial, industrial or recreational areas (Commission Implementing Regulation (EU) 2019/947).

As of 2016 the U-space framework has been established in order to address both future regulation development as well as technologically required adherence to the regulations (Huttunen, 2019).

3.1 U.S.A. Regulations

In the USA the regulations about Unmanned Aircraft are under Federal Aviation Administration (FAA). The responsibilities of FAA are regulating civil aviation to promote safety within the U.S. and abroad. In U.S. Unmanned Aircraft need to be register if it weighs more than 0.55 lbs. (250 grams) and less than 55 lbs. (25 kg). For commercial flights is required a commercial pilot's certificate issued by the FAA. Some operational limitations by rule 107 are that flying is permitted only in Class G unmonitored airspace. Regulations also determine that the maximum flying altitude is 400 feet (120 m). The UAS must always be able to be seen by its operator without using binoculars. Flying is permitted only in daylight for a UAS without lighting. Flying is allowed in civil twilight if the UAS has lighting. Flight speed is limited to 100 mph (160 km/h) or less. Preference is given to manned aircraft and flying directly over people it is not allowed ("Summary of Small Unmanned Aircraft Rule" (Part 107) [FAA News], 2016).

4. UNMANNED AIR TRAFFIC MANAGEMENT (UATM)

The current procedure to perform UAV flight mission for personal, or commercial use requires applying for a flight permit in advance, which can be time consuming and requires a lot of manual work. As such, this approach also does not provide any real capabilities for monitoring the flight missions or detect potential hazards to the UAVs themselves or more importantly, hazards to the civilian population or the environment. To provide a systemic approach to handle both approval as well as detect hazards while on mission we propose an IT platform that will manage all aspects required by the regulations and provide a solid foundation to monitoring of ongoing UAV flights. The proposed platform follows the U-Space guidelines.

4.1 UAV flight registration

The UATM platform will require the UAV operators to register online by providing a valid license. Along with operators, any UAV that is intended for use must also be registered, providing data such as manufacturer, model, battery type/capacity, battery status, maintenance log, acceleration, top speed, etc.

An operator must log on to the platform in order to apply for a flight mission where he needs to upload the following data:

- UAV ID
- UAV operator ID
- Starting location
- Destination location
- Cargo type
- Requested sensor use
- Mission purpose

Depending on the provided data the system checks the provided data in order to either approve or deny the flight mission request. For the system to approve the flight application the license validity check for the operator is performed as well as battery status for the UAV. While the operator uses a mobile application for communication and flight requests, the UAV must also maintain a constant uplink with the platform in order to send its main information for flight approval, and later for flight control. With a valid operator and UAV status (proper battery voltage, error checking, etc.) the next check is on the start and destination locations and whether a safe route between both points can be generated – the route must not cross no-fly zones, protected environments in case of hazardous cargo, avoid watery areas, populated areas etc. Another issue that needs to be addressed is the use of sensors and privacy concerns. While the system automatically analyses the data for a requested UAV flight and proposes an approval or denial based on hazard checks it can automatically confirm the flight, or provide the suggestion to an UATM administrator for further study.

Once a UAV flight mission is approved the flight must take place under strict supervision by the UATM system. For this purpose, the UAV operator must be provided by restrictions, which he must comply with at any time while the mission is on. The requested flight mission data that is processed by the platform service generates the complete mission description that needs the actual UAV flight is required to follow strictly. The approved mission includes:

- UAV flight mission ID
- Emergency landing locations
- Hazard assessment
- Allowed sensor use
- Mission start time
- Flight route
- Flight time window

The flight route or corridor is generated depending on the requested starting and landing location. While a straightforward approach would be to generate the route by elevating vertically from the starting location to a maximal allowed altitude, then translating to the destination location and lowering to the ground, terrain or surface features may provide obstacles. Furthermore, depending on the cargo type, certain areas above the terrain may need to be avoided. For this purpose, the platform generates the flight route over a 3D terrain hazard map, avoiding areas which could pose an environmental or safety hazard. Along with the flight route a time window for the UAV mission is generated, requiring during the active mission that the UAV passes certain areas of the flight route at a predefined time. The generated flight route and its complementary time window is checked for intersections with any other approved or active flight routes by other UAV missions. If there is a possibility that two (or more) UAVs might cross each other paths within a reasonable time frame the mission request is either declined or the start (and the whole time flight window) is postponed to such a time where no critical intersection is expected. The allowed sensor use may be overridden from the requested one in order to comply to privacy requirements. For instance, a requested camera use or recording may be declined near a populated area.

4.2 Active UAV flight mission monitoring

During a flight mission the UAV must keep a constant connection with the UATM system, and send telemetry data at regular intervals that among other includes:

- UAV flight mission ID
- GPS location
- GPS time
- Battery voltage
- Active sensor status
- Accelerometer data
- Vibration measurements data
- Events

At any time, the system must provide capabilities to collect data from all active UAVs and detect any hazards that appear. This includes checking whether each drone is at the expected place at the expected time – following its predefined flight route and flight time window. Although the system should not allow crossing of different flight routes, additional checks are made to detect if GPS positions of UAVs are entering the safety area of other drones, in which case the operators are prompted to pay attention to the activities, to alter their course, or to perform an emergency landing.

Similar measurements can be taken at other events, such as a sudden drop in battery voltage, spikes in accelerometer data, which indicated unexpected events such as high winds, performance issues, or any other events that can be detected by UAVs on-board sensors.

With all telemetry data being sent and stored at the platform, the system provides an external black box with any events stored in the database for all active flights providing an audit trail to check for any inconsistency. The proposed UATM system can provide grounds for the changing of existing regulations to allow a broader use of UAVs for commercial and civilian use, while maintaining a high security level and minimizing exploitations. All UAV use would need to register on the proposed system, which would provide a strict overview of the UAVs, their condition, maintenance records, batteries status, which can provide an environmental as well as safety hazard.

As any UAV in use as well as the operator need to be registered determining the responsible parties in case of accidents can be backtracked by analysing the logged data. All flight data uploaded to the UATM database can be used for later analysis of any incidents. Regulations should require that only registered operators and UAVs be allowed UAV activities as any other, including for recreational use may pose a collision threat. By tracking the GPS position of any active UAV, the system can be used to provide data to other parties of interest such civil flight institutions, in order to prevent collision for instance with helicopters active in the same area, although generally the system should avoid such occurrences by force landing or redirecting active drones. In case of the operators not complying with the instructions by the UATM, either engaging in not allowed recording or straying off the designated route the system sends warning message. Continued ignoring of the warning should be penalised by paying fines according to the transgression or even by revoking the license or confiscating the UAV.

While the proposed system produces the directions that need to be followed by the operator, a possible solution to prevent abuse is by programming the drones to adhere to the UATM override signal. In this case the system would check against recurring irregularities in the flight plan (position, active camera/recording, etc.) and send the signal to force a landing at one of the generated emergency landing sites, while notifying the authorities about the incident. Any airborne drones not managed by the system should be considered as intruders in the airspace that pose a threat to population and legally operated UAVs.

As drones can share the airspace with other members such as gliders paragliders, balloons, a valid consideration is to require all participants apart from civil aviation to use UATM system. While the UAVs can communicate via the ground station or other participants can use mobile devices for communication with the UATM. Any airborne participant could receive proximity warnings and as such provide a complete control over the airways.

4.3 Digital twin UATM solution

As stated previously a digital twin is a digital representation of the physical processes that take place in the real world. Modelling those processes and analysing their outcome digitally can provide a safe and reliable alternative compared to observing actual processes that may have a negative impact. Foreseeing unfavourable events with a digital can be used to avoid them or find better alternatives.

In the case of the presented UATM solution, the system oversees the active UAVs and triggers alerts in case of detected hazards. Technically, this description alone could classify the UATM system as a digital twin as it provides a digital footprint of actual drone positions as well as their properties, thus allowing a digital overview of the current situation. The added value of the digital twin solution lies in the anticipation of future flight mission along with observing currently airborne drones. As the generated flight routes, either active or upcoming are all supplied with time windows, the digital twin can predict the risk of drone collisions, identify increased risks due to impending weather changes by observing weather station data, or as a consequence of such data re-evaluate risks to the environment or civilian population. As such the digital twin both depicts the current events as well as performs regular checks for any events and their consequences, thus providing a systemic solution to avoid preventable accidents or minimize their outcomes.

An important issue with the proposed surveillance method presents the level of automation. Ideally any transport flight mission should be completely automated, with the operator only defining the mission, while all the flight instructions should be uploaded to and handled by the drone, with the operator overseeing the mission. While fully automated drone use is possible the regulations generally do not allow fully autonomous operations. And drones must be controlled by flight on vision. A fully autonomous UAV that conforms to the proposed UATM system would minimize the human factor and eliminate the possibility of human error. The automation of UAV mission would require the development of standards that the UAV manufacturers would need to comply to. While the current regulations require the operators to control their drones manually, the communication must involve the UATM system, the UAV as well as the operator. As such the responsibility for the flight mission lies with the latter.

4.4 UATM response in emergency situations

Drones can be employed in various emergency response scenarios. They can be used to provide necessary medical supplies to unreachable sits due to terrain features or heavy traffic, provide monitoring of forest fires, support in search and rescue or other situations where it is important to provide critical information on time.

Appropriate institutions must be able to employ their drones safely to offer the best possible support for the emergency response. As such the UATM system must provide them with a priority status, in which case any pending requests within the emergency locality are cancelled or delayed to a time where the emergency is expected to be over. The UATM identifies any active UAVs in the locality and analyses any potential interference with the emergency UAV mission. All active drones that could pose a hazard for the emergency operations are signalled to perform an emergency landing at a predefined emergency landing site, unless a safe route without interference risk can be generated and for the drone to evacuate the area safely. While today's use of drones may not present a heavy traffic burned, let us consider a possible future with a broad use of drones for packet deliveries or other commercial use with numerous active drones at any time. The UATM must be able to track all drones and in emergency cases force them to land or evacuate in order to provide clear airways for emergency UAV missions.

4.5 UATM in Smart cities

Ever increasing population in cities requires adapting to increased traffic, service needs, emergency management, and safety and security requirements. With recent development in UAV use for last mile delivery a future with continually present UAV activity is quite probable. Whether these drones will be operated manually or completely automated, a control system will be necessary to ensure a safe inclusion of the drones into the everyday life, with minimal risk to the population, the environment, or public and private property. Integrating the UATM into the Smart city solution allows the access to the data is not limited to the UAVs and air traffic, but also provides an overview to other events in the city. As such the UATM can quickly adapt to various hazard situations, clear the airways in case of priority emergency requirements, schedule the UAV missions in order to prevent or reduce aerial overcrowding or to reduce the noise. Integrating the UATM with the Smart city would also mean that other institutions would be instantly notified about any incidents taking place, which would allow them to respond appropriately in time.

5. CONCLUSION

The current and expected future growth of UAV use will require an efficient approach for unmanned air traffic management that will ensure maximal safety for the civilian population, the environment, as well as public or private property. While the current limitations set by the active legislature are bound to be altered in favour of UAV use, it is imperative that a solution for active monitoring of UAV activities is employed. This approach provides a foundation based on which the legislature can be adapted to allow a broader use of drones, while at the same time it provides a safe environment for all participants. The digital twin approach for the development of the UATM system enables for a complete overview of the aerial activities and allows anticipation of future events, reaching a high level of surveillance and thus maximizing the safety and security. The digital twin approach enables a foundation of integration of civilian services that increases both safety as well as security in aerial and terrestrial environment. Further development should oversee optimization using smart path generation and flight scheduling for UAV fleets and integrated communication with the civil aviation agencies to minimize any hazards.

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RISK MANAGEMENT IN A LOGISTICS COMPANY

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Keywords: risk, risk management, risk mitigation, risk analysis, logistics.

1. **ABSTRACT:** The current paper presents the risk management process applied to a Romanian logistics company, one of the most prominent Romanian railway operators. The company was presented, then ten main risks were identified and described. The risks were assessed based on the risk index and risk matrix methods. Their probability of occurrence and their impact were assessed, thus computing the risk index. The generic risk management strategies were generated after plotting the identified risks on the risk matrix. Following the risk analysis, more specific mitigating solutions were advanced, aiming at eliminating the critical risks and attenuating and treating the most tolerable ones. The authors discussed the results and presented relevant conclusions for the analysis. This risk management process can be applied to virtually any logistics company, irrespective of its area of operations.

2. INTRODUCTION

Risk assessment and modeling is a complex, multidisciplinary process that encompasses several fields, such as technological, economic, sociological or political. The results obtained through this process significantly influence the decisions and strategies taken by companies at the macro and microeconomic levels (Kaplan, Mikes, 2012).

The risk concept underwent changes, as the notion evolved from signifying damage, adverse events or losses, to that of the probability of an event that could impact the organization, and then to the uncertainty regarding the company's objectives (Aven and Renn, 2009, 2010).

Therefore, according the International Organization for Standardization (2009), the risk is an uncertain event that, if materialized, can have positive, negative, or uncertain effects on the objectives of the company's activities. It arises either because an unforeseen event occurred during that activity, or because an event that was planned did not unfold as planned. However, the opinion of experts and specialists regarding these three risk connotations (threats - opportunities – uncertain consequences) differ (Deselnicu, 2019, p. 12-14).

3. THE RISK CONCEPT

According to the Merriam – Webster Dictionary, the term "risk" originates from the French *word "risque" and the Italian "risco",* which signify *"*a possibility of ending up in a danger, of facing a trouble or suffering a loss". Other authors say that the term risk has another meaning in economic activity, namely: "a wide range of uncertainties regarding the future activity of an economic agent". It is highlighted that the risk is nothing but the inability of the organization to adapt, in due time and at the lowest costs, to the variations of the environmental conditions (McNeil, Frey, Embrechts, 2015).

Forecasting and managing situations under risk conditions are the most important functions of risk management (Dumitrescu, Deselnicu, 2018). Risk management is represented by a process of identifying, analyzing, and evaluating risks, as well as advancing mitigating actions to control them (Institute for Risk Management, 2022). In situations where clear decisions must be taken, the manager must assume the decision-making role and outcomes, even if the circumstances or the necessary data are partially known. After this decision is made, some uncertainty remains as to the expected results.

The first stage of risk management is identifying the risky events. This activity involves creating a list that includes the risks that can affect the organization, followed by their evaluation, and finally their assessment. The process of managing these risks must be a permanent one because new risks can constantly appear and they need to be controlled in order to allow the normal development of the company's activity (Wiengarten, Humphreys, Gimenez, McIvor, 2016).

2. RISK MANAGEMENT IN A ROMANIAN RAIL FREIGHT TRANSPORT COMPANY

2.1 Company description

Eastern Europe presents itself as one of the growing European markets. Based on this development, many international companies, such as those in the automotive industry, have decided to develop their production units in this area. Deutsche Bahn Cargo (DB Cargo) is the European number one company in the freight industry and the largest operator in terms of volumes transported in Europe. It established its own transport operator in Romania, as part of the European DB Cargo network.

Deutsche Bahn Cargo Romania has been active in Romania since 2000, initially operating as Logistic Services Danubius (DB Cargo, 2022). From February 2003 to February 2009, the organization also carried out railway shunting activities in Bulgaria. In September 2003 and July 2004, two more important contracts were signed for the railway shunting, determining the construction of two more work points established in Deva and Alesd (Romania). In August 2006, the company obtained a railway carrier license in Romania, and since December 2006, it has been carrying out train towing activities for domestic traffic. The company continued to develop: in 2009, the office in Bucharest was established. In May 2011, the name of the organization changed from Logistic Services Danubius to DB Schenker Rail Romania SRL. Aiming to offering customers a superior service, in the summer of 2012, DB Schenker Rail Romania built its own depot in Turceni, Romania.

Supporting its upward trend, DB Schenker Rail Romania's vision is to be a railway operator that provides superior quality services, is reliable for customers, safe for employees, economically viable and sustainable for the environment, owns a fleet of wagons and locomotives impressive in number and performance.

In Bucharest, all transport and local delivery services are managed and planned in a dedicated control center, by the company's staff. The focus is on national and international traffic, working with companies in industries such as construction materials, metallurgy, automotive, and grain. Deutsche Bahn Cargo Romania possesses the important safety certificates to operate on most of the Romanian railway networks.

2.2 Products and services offered by the company

DB Cargo Romania operates nationally and internationally in the field of freight transport by rail. It has a fleet of approximately 60 locomotives (Diesel, Diesel-Electric, Electric) and over 2000 wagons. The services offered by the company are related to rail freight transport. Customers benefit from the following modes of transport:
- Insulated wagons and locomotives;
- wagon groups of: between a minimum of 5 wagons and a maximum of 10 physical wagons;
- multigroup trains comprising more than two groups of wagons, they travel together on an important segment of their established routes;
- complete trains, they are composed of wagons that run between the same dispatch station and the same destination station, comply with route-specific minimum tonnage or minimum length conditions and have a single fare payer.

DB Cargo Romania works with approximately 55 active clients, of which 20 have high volumes and constant activity. They are from several industries such as automobiles, containers, grain, cement, and metallurgy. The transported products are different; therefore, the transport is carried out differently, using certain types of locomotives or wagons. The transported products include construction materials, chemicals, fertilizers, industrial and consumer goods, metals, and coal, but also components and vehicles.

2.3 SWOT analysis of the company

As far as this analysis is concerned, all the real elements will be scored, which actually add to the company or can harm it. The strengths of the organization will be presented are:
- Low operations costs;
- Effective, customer-oriented management, due to the reduced hierarchical levels;
- Reliable and well-known collaborators, for which transport services are provided (Ford, Dacia, Renault, ArcelorMittal etc.);
- Qualified, efficient and passionate staff;
- Good financial situation;
- The fleet is composed of different types of locomotives and wagons, thus the transport can be carried out differentially, serving a varied market segment;
- Strong organizational culture;
- Own fleet;
- Own depot that ensures the maintenance of rolling stock.

The identified company's weaknesses can be summarized as follows:
- Accommodation is not provided for the trains staff;

- There is not enough transport capacity in the grain season;
- Maintenance of diesel locomotives is carried out by partners;
- The need to adapt the rolling stock;
- Lack of specialized wagons for transporting petroleum products;
- Reduced possibilities of external financing.

Opportunities from the external environment that can influence the company's activity are as follows:

- The permanent consolidation of the industry has opened up new prospects for business on new routes;
- Rail freight is the cheapest compared to other modes of transportation;
- Customer loyalty by offering discounts depending on the desired services.
- Companies are increasingly interested in rail freight transport;
- Increasing demand for grain transportation, and the company is able to offer these services.

The threats that can affect the organization's activity are:

- Market entry of other railway transport companies;
- Certain important railway transport companies have opted for low-cost transport in an attempt to reposition themselves in the railway transport market;
- Exposure to the infrastructure regulations and to the compensation requested by the clients;
- The infrastructure usage fee generates large costs;
- The electricity grid connection increasing fee generates higher operating costs;
- Railway regulations and regional policy.

Following the SWOT analysis, it can be concluded that DB Cargo Romania benefits from numerous important strengths and favorable opportunities. However, it is also confronted with internal weaknesses and external threats that can become vulnerabilities and risks that the company must clearly identify and overcome.

3. RISK MANAGEMENT OF THE DB CARGO ROMANIA

3.1. Risk identification

One of the most important incipient stages of the risk management process is risk identification (Cioca *et al.,* 2018). Based on the previous experience of managers in the company, ten relevant risks have been identified and described:

❖ **R1. Axle breakage in motor or towed railway vehicles**

Causes: failure to carry out or superficially carry out the planned overhaul for locomotives, carrying out the control with an unverified metrological device, not introducing the wagons for the overhaul when due, improperly carrying out repairs during the overhaul of the wagons.

Responsible: Maintenance department and dispatch department through supervisory actions.

❖ **R2. Exceeding regular traffic speed**

Causes: fatigue due to exceeding the maximum service allowed on the locomotive.

Responsible: Dispatch Department, training and control staff.

❖ **R3. Overcoming stop signals**

Causes: lack of concentration when following the route due to fatigue and exceeding the work schedule, human error, deviation of attention from following the route, and off-duty discussions with the assistant mechanic.

Responsible: Dispatch Department, training and control staff.

❖ **R4. Failure to follow the line and course in traffic**

Causes: tiredness/low attention due to exceeding the maximum allowed service on the locomotive, off-duty discussions with the assistant mechanic.

Responsible: Training and control staff, Dispatch Department.

❖ **R5. Failure to adapt traffic speed to visibility conditions**

Causes: Locomotive staff ignore safety precautions under the pressure of delivering the goods to the consignee.

Responsible: Dispatched Department, training and control staff.

❖ **R6. Breakdowns of the en route locomotive**

Causes: poor maintenance of locomotive sub-assemblies and circuits, the unauthorized intervention of locomotive personnel on locomotive sub-assemblies and circuits, locomotive leaving from the traction units with faults of the electrical equipment, the use of improvisations to remedy some locomotive defects, failure to carry out the planned revisions at the established and approved terms, carrying out revisions without respecting the guidelines included in the nomenclature of approved revisions.

Responsible: Maintenance department, locomotive operation service and staff, training center and staff with training duties.

❖ **R7. Movement of loaded goods in the wagons**

Causes: Inadequate verification of the insurance of the loaded goods, the use of non-compliant devices when securing the goods.

Responsible: Training and control staff.

❖ **R8. Theft of goods from wagons**

Causes: Failure by the transport operator to guard the train in stations or in some traffic sections.

Responsible: Guards of the trains operating on the problematic railway sections.

❖ **R9. Danger of fire at the locomotive**

Causes: Failures manifested under load operating conditions are not identified, not all static tests are performed in order to identify the operating parameters of the locomotive, tests are performed by unqualified personnel or under time pressure, and some checks are omitted.

Responsible: Maintenance department.

❖ **R10. Hitting vehicles during the shunting activity over the level crossing with the railway**

Causes: Personnel negligence, ignorance of regulatory provisions, ignorance of the characteristics of the maneuvering area.

Responsible: training personnel.

These risks cannot be tolerated, as they have very severe consequences, from damage to vehicles to significant material losses and even losses of human life.

3.2. Risk assessment

After the risks have been identified, their evaluation was carried out to find out their appropriate mitigation methods, but also to identify the precautionary methods by which their occurrences can be avoided. First, the risk index was calculated using the formula taking into consideration the probability of occurrence of the risk and its impact (Campbell, 2005; Hopkins, 2010). Values between 1 and 10 were assigned for Probability (where 1 represents the least likely and 10 very likely), and for Impact (1 signifying low/low impact and 10 a catastrophic impact). The Risk Index (R_I) was calculated using formula (1):

(1) $$R_I = Likelihood \ x \ Impact$$

Table 1 shows the values assigned to each of the identified risks for probability and impact and calculates the corresponding risk index:

Table 1. Calculation of the risk index (R_I)

	R1	*R2*	*R3*	*R4*	*R5*	*R6*	*R7*	*R8*	*R9*	*R10*
Probability	3	7	7	2	6	7	3	3	2	6
Impact	8	7	8	10	9	4	8	7	9	10
Risk index (R_I)	24	49	56	20	54	28	24	21	18	60

Source: Authors' contribution

As can be seen, the highest values of the risk index are associated with R10 - Hitting automobiles during the maneuvering activity over the level crossing with the railway and R3 - Overcoming stop signals, while its lowest values are associated with R4 - Not following the line and the route in circulation and R9 – Danger of fire at the locomotive.

Next, the values obtained by the risk index for each risk will be represented on the Risk matrix (Figure 1):

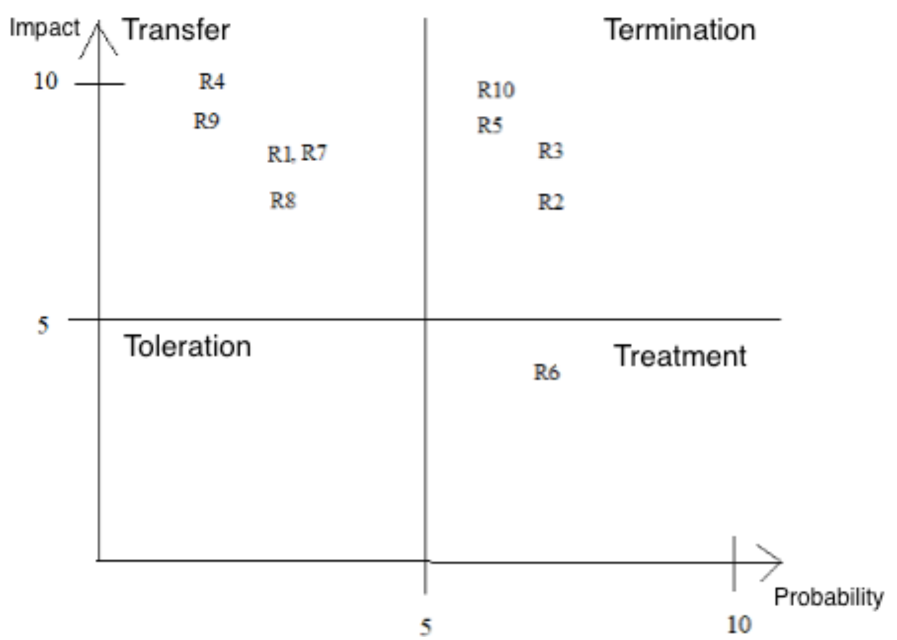

Figure 1. Risk matrix. Source: authors' contribution

As can be observed, most of the risks that the company is confronted with have a high probability and impact, making them hard to tolerate and calling for immediate action.

3.3 Risk management

The placement of the risks on the matrix also suggests the most appropriate generic risk management strategies which need to be adopted for them (Bandle, 2007). As deducted from Figure 1, no risk can be tolerated by the company, as none of them fall in the lower left quadrant. Only R6 - Breakdowns of the en route locomotive falls into the Treatment quadrant. Risks R2, R3, R5, and R10 are positioned in the Termination quadrant, while all the other identified risks are plotted in the Transfer strategies quadrant. Table 2 the appropriate strategies to be addressed corresponding to each identified risk:

Table 2. Strategies for risk management

Risk	*Risk management strategy*
R1. Axle breakage in motor or towed railway vehicles	Transfer
R2. Exceeding regular traffic speed	Termination
R3. Overcoming stop signals	Termination
R4. Failure to follow the line and course in traffic	Transfer
R5. Failure to adapt traffic speed to visibility conditions	Termination
R6. Breakdowns of the en route locomotive	Treatment
R7. Movement of loaded goods in the wagons	Transfer
R8. Theft of goods from wagons	Transfer
R9. Danger of fire at the locomotive	Transfer
R10. Hitting vehicles during the shunting activity over the level crossing with the railway	Termination

Source: Authors' contribution

As generic risk management strategies are just an indication of the solutions to be applied, the authors further developed specific mitigation solutions for each of the identified and evaluated risks (Table 3):

Table 3. Solutions to mitigate the identified risks

Risks	*Mitigating risk solutions*
R1. Axle breakage in motor or towed railway vehicles	Ensuring contracts with repair entities
	Complying with the procedure for recording measuring devices, marking the measuring devices with the due date for checks
	Ensuring that repairs are carried out by qualified personnel
R2. Exceeding regular traffic speed	Daily verification of staff orders, in electronic format
	On-site verifications of compliance with rest, duty times, waiting times
	Ensuring that the locomotive staff is aware of this risk, establishing clear guidelines for controlling the communication in the locomotive cabin

Risks	*Mitigating risk solutions*
R3. Overcoming stop signals	Permanent monitoring of speedometer strip records and establishing rules for with personnel who does not comply with traffic regulations;
R4. Failure to follow the line and course in traffic	Awareness of the staff of compliance with the duties of service, validation by attendants and control actions.
R5. Failure to adapt traffic speed to visibility conditions	Control actions to identify staff who tends to ignore safety measures;
	Strict actions to ensure that staff respects
	Staff awareness that when towing the train, the most important thing is to reach the destination safely, not in the shortest time.
R6. Breakdowns of the en route locomotive	Provision of spare parts and materials according to operating terms;
	Verification of the way of carrying out intermediate revisions;
	Permanent monitoring of locomotives and collaboration with the dispatcher for their withdrawal.
R7. Movement of loaded goods in the wagons	Staff awareness of not admitting wagons with uninsured goods to transport;
	Checking anchoring devices for their integrity and not accepting improvised devices that do not conform to established standards.
R8. Theft of goods from wagons	Identification by company management of CF stations or haulage sections that are flagged as having problems. Ensuring the security of these trains in the identified stations.
R9. Danger of fire at the locomotive	Entry in the log book of irregularities manifested in the operation of the locomotive;
	Checking the knowledge of the personnel performing the maintenance activity.
R10. Hitting vehicles during the shunting activity over the level crossing with the railway	Training staff not to deviate from all mandatory activities in a case. Instructing the staff to request a second agent in the event of a breakdown of the means of communication.

Source: Authors' contribution

As can be observed, for each risk solutions were offered to reduce its probability or reduce its impact. All the suggested mitigation methods aim at minimizing the probability of occurrence of the risky events and of the consequences that may arise in the event of their materialization.

4. CONCLUSIONS

The paper presents the risk management analysis process for one of the most prominent Romanian logistics railway operators, DB Cargo Romania. The analysis included the identification and description of risks, and their evaluation according to the probability of occurrence and impact (consequences). Ten risks were identified, including axle breakage in motor or towed railway vehicles; exceeding traffic speeds; overtaking stop signals; not following the line and route in traffic, not adapting the traffic speed to the visibility conditions; breakdowns of locomotives en route; moving the loaded goods in wagons; theft of goods from wagons; the danger of fire; hitting vehicles during the shunting activity over the level crossing with the railway. All these risk factors were analyzed and evaluated, and solutions were advanced to counteract them so that their probability of occurrence decreases, and the impact no longer affects the company in a disastrous way.

The most threatening risks identified were R10 - Hitting automobiles during the maneuvering activity over the level crossing with the railway and R3 - Overcoming stop signals. These risks are critical and cannot be tolerated. The lowest values are associated with R4 - Not following the line and the route in circulation and R9 – Danger of fire at the locomotive. Although dangerous in themselves, these risks are not as critical as the others, as they have a low probability of occurrence.

One of the main conclusions is that most of the risks that the company is facing have both a high probability and a high impact, making them difficult to tolerate and asking for urgent and efficient mitigation methods. Therefore, generic, as well as specific mitigation strategies were proposed for all identified risks in order to reduce both their probability and their impact. By implementing the recommended risk management solutions, the company can reach a tolerable residual risk level. This risk management process can be applied to virtually any logistics company, irrespective to its area of operations.

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P-ISSN: 2682-3764