Navigating the Future: Digital Transformation, Sustainability, and Critical Thinking in Maritime Management

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Editor: Prof.Dr. Gönül YÜCE AKINCI

ISBN: 978-625-372-490-0

Page Layout: Gözde YÜCEL

1st Edition:

Publication Date: 25.12.2024

BIDGE Publications,

Certificate No: 71374

www.bidgeyayinlari.com.tr - bidgeyayinlari@gmail.com

Krc Bilişim Ticaret ve Organizasyon Ltd. Şti.

Güzeltepe Mahallesi Abidin Daver Sokak Sefer Apartmanı No: 7/9 Çankaya / Ankara

Content

CHAPTER I

A research on the perspectives of team leaders about the concepts of digital transformation.

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Introduction

Organizations have experienced global changes in recent years due to factors like technological advancements and increased digitalization (Hervé, Schmitt & Baldegger, 2020). Unlike the formal structure, the current developments on the agenda also influence leadership. Daily life frequently encounters concepts such as the internet of things, artificial intelligence, cloud data, smart

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robots, drone technologies, mobile transactions, and big data. Organizations can also use these concepts as tools to influence and coordinate audiences. Therefore, the impact of technology, especially in leadership approaches, is among the main issues that need to be examined and analyzed (Tagscherer & Carbon, 2023). With the increase in digitalization, question marks have begun to arise about the future of many business lines in organizations. Organizational functions such as marketing, accounting, finance, production, and human resources are advancing towards digitalization day by day, and organizations need to be open to innovations in order to be sustainable (Kiron et al., 2016). In order to keep up with the competitive environment, it is of extreme importance for organizations to focus on innovative activities compatible with their own culture. Leaders must face challenging tasks in order for organizations to adapt to digitalization and the needs of the generation (Khan, 2016).

Advances in technology lead to changes in leaders' managerial tasks. Although the increase in digitalization provides great support for leaders to carry out their duties, it threatens abilities such as creativity, flexibility, intuition, and spontaneity, which are important for organizational development. With digitalization, the roles of team leaders have begun to gain importance, and their central decision-making power has become more effective, thanks to the advanced data collected from customers, employees, and competitors (Nell et al., 2021). Organizations need strong leaders who can stand at the helm in stormy business environments. Experienced leaders must not only express a vision around which individuals can rally but also find the best talent and ensure employees work at their highest efficiency. If leaders are successful

in these subjects, they will also create the conditions that make digital maturity possible (Kane et al., 2019).

This study aims to bridge the gaps in the relevant field and illuminate future research by examining the digitalization awareness levels of organizational team leaders, a topic that has received minimal attention in both domestic and foreign literature. We conducted online interviews with eleven team leaders from private enterprises in Türkiye for this purpose, and used the content analysis technique to conceptually analyze the data obtained during the interviews. The level of knowledge and awareness of team leaders in Türkiye about digitalization is important in terms of guiding the next generation and making suitable decisions. One of the study's secondary goals is to raise awareness of the concept of digitalization among leaders.

Concept of Digitalization

Developments in smart devices and social media platforms, it has led to a great shift in the methods customers use to communicate with businesses, as well as customers' expectations regarding response times (Hajli, 2019; Voramontri & Klieb, 2019). Businesses have now begun to see that they can communicate digitally with their customers individually and in real time. Digital payment alternatives have increasingly enabled online commerce and created opportunities for web-based points of sale. Today, the focus is on mobile devices and creating value for customers by taking advantage of the personalized customer data that mobile technologies can produce. Businesses benefit from this personalized information and can better tailor their products, communications,

and interactions to customers' specific needs (Christl, Kopp & Riechert, 2017; Schallmo, Williams & Boardman, 2017).

Digital transformation is a topic that remains current for companies around the world, meaning the use of technology to radically improve the performance of businesses (Schwertner, 2017). Leaders across all industries are using digital tools such as big data, artificial intelligence, the Internet of Things, social media and smart devices to transform customer relationships, internal processes and values. Aware that digital technology has disrupted media industries over the last decade, team leaders need to be very attentive to the changes occurring in the industry (Westerman, Bonnet & McAfee, 2014). Digital transformation consists of the combined effects of various digital innovations that change, threaten, and introduce new actors, structures, practices, values and beliefs in organizations, ecosystems and industries (Hinings, Gegenhuber & Greenwood, 2018). Most companies aiming for digital transformation are using digital technologies to increase efficiency in a job the company is already doing. These activities include activities such as increasing marketing expenditures for digital channels or improving internal communication systems. On the other hand, in order to achieve digital transformation, companies need to change their working methods, especially around customer interactions and the way this interaction is created. For example, it is known that the Apple brand uses developer networks to create software for its devices (Libert, Beck & Wind, 2016).

Digital transformation strategies have recently gained different perspectives and pursued different goals. These strategies, used from a business-centered perspective, focus on the

transformation of products, processes and organizational aspects thanks to new technologies (Shaughnessy, 2018). They are designed to be broader in scope, such as digital technologies that are part of final consumer products. It also includes digital activities that are completely at the customers' disposal. Since digital transformation strategies surpass the process paradigm, this makes a difference in terms of process automation and optimization. In addition, it includes changes in products, services, and business models and their related consequences (Matt, Hess & Benlian, 2015). Digitalization is the simple process of converting analog information into digital by scanning a document or uploading an audio recording. It can also generally carry out the process of moving a process from manual to digital. It does things like replace hand-filled forms with online versions that allow them to be entered directly into a database. Paperless offices, which are much talked about and always difficult to implement, are one of the points of digitalization. On the other hand, digitalization refers to the use of digital technology and possibly digitized information to create and harvest value in new ways (Gobble, 2018). In today's data-driven world, companies are being forced to reconsider many of their old assumptions. For example, Airbnb realized that when it moved away from processes and focused on data, the company did not need to own physical assets (hotels). The features that enable a hotel business to be competitive in a process-oriented world are invalid in a data-oriented world (Bendor-Samuel, 2017).

It is necessary to seek the help of digitalization experts in making digital transformations sustainable. Mastering three different aspects of digital transformation will help maintain the momentum

of transformation. The steps to be followed are listed as follows (Westerman, Bonnet & McAfee, 2014):

Building core capabilities: Organizations need to have a plan to increase their digital capabilities. Apart from these, it is also important that they have a well-structured digital platform and a strong business relationship with information technology (IT).

-Aligning reward structures: Organizations must implement encouraging and rewarding practices towards employees and these activities must be in harmony with digital transformation goals.

-Measurement, monitoring and iteration: There must be a management process that allows measuring the progress of digital transformation. It is also important to have sufficient foresight to properly adopt the goals.

Ultimately, what all digital transformation predictions have in common is change. Although it creates more opportunities than ever before, a new mindset and readiness to embrace change is required to realize digitalization. Both companies and individuals must accept the new reality of constant change in order to find a place in the evolving digital world (Auriga, 2016).

Digitalization from the Management Perspective

Digitalization is a process dependent on technological infrastructure and progress. This feature strengthens its potential to influence the organization as a whole. Coordination and synergy between functions increases the expected benefit from this process as much as possible. The will of the management and the leader in decision-making and the initiative on the units reveal their responsibility for digitalization (Rêgo, 2021). The focal point and

critical success factor of the digitalization process is attributed to the management approach. Management attaches more importance to technical capability and innovation processes in the digitalization process. Therefore, conducting research in technological fields such as informatics and innovation in businesses has started to gain great importance. Business models and strategies are needed to move the issue forward in digitalization processes (Grab, Olaru & Gavril, 2019). It is thought that the information systems discipline's combination of these views is compatible with the objectives of the business. Since the development of information systems, roles that provide support to the management field have become of great importance (Hausberg et al., 2019). Companies should ensure that team leaders who are operationally responsible for the digital transformation strategy have sufficient experience in transformation projects. In addition, team leaders must be in harmony with the strategic goals of the company. To date, there has been no clear answer as to which senior executive should be responsible for a digital transformation strategy. Potential candidates include CIO (Chief Information Officer), CEO(Chief Executive Officer), CDO(Chief Digital Officer) and business transformation leaders (Matt, Hess & Benlian, 2015). To navigate the complexity of the digital business world, companies must embrace the concept of digital alignment (people, culture, structure and tasks aligned with each other). This will enable team leaders to effectively address the challenges of an ever-changing digital landscape. As a result, the work of team leaders to create adaptation for the digital age in organizations and how these efforts will lead to changes in organizations arouses deep curiosity (Kiron et al., 2016).

Leadership before digitalization is classical leadership. Digital leadership, which begins with digitalization, includes both the digital transformation process and managing the organization in a digital environment. The more digital transformation is completed, the more direction a digital organization needs to take. Once the digital transformation is over, the organization will be completely digital and leaders will have the mission of leading a digital-only organization. Today, the majority of companies have entered the transformation process. Digital leadership means both leading digital transformation and managing the organization in the digital environment (Klein, 2020). Digital strategy is a business strategy inspired by powerful, easily accessible technologies to deliver unique, integrated business capabilities to respond to ever-changing market conditions. A digital strategy guides companies' efforts to create new value propositions by combining existing capabilities with the capabilities of other digital technologies (Sebastian et al., 2017).

Digitalization is perceived as both a global destroyer and a focus of opportunities that will be a source of new formations. Apart from these, it leads to a profound transformation in business requirements. As a result, leaders need to invest in developing employees' skills in order to support and motivate them in the face of cognitive challenges (Cortellazzo, Bruni & Zampieri, 2019). To achieve ambitious goals, leaders focus on the often overlooked workforce factor. It sees technology as an enabler to transform its employees, projects and organizations into a business that is extremely positive and ready for change. In short, business leaders are realizing that the new digital workforce can become the new competitive advantage (Sainger, 2018). Today's best-known CEOs

personally create products, services or unconventional ideas. Well-managed companies invest heavily in enabling communication between strangers within their borders, hoping that average employees will develop ideas that will turn into new businesses (Leavy, 2020).

Sample of the Research

This study aimed to evaluate the awareness levels of team leaders working in the private sector in Turkey about digitalization processes. Research data was obtained using the purposeful sampling method. Purposive sampling refers to the sample formed by individuals with the most suitable sample characteristics for the research purposes. In the purposeful sampling method, sample criteria are determined by the researcher in accordance with the research structure (Yıldırım & Şimşek, 2016). The sample of the research consists of team leaders in companies operating in the private sector in Turkey. For the purposes of the research, 103 different organizations were contacted and the opinions of 11 team leaders who responded on a voluntary basis from these organizations were consulted. Participants in the research were informed in advance that no personal data would be requested or shared during the research process.

Data Collection Method

In this research, fully structured interview, one of the qualitative research methods, was used. In this type of interview, researchers systematically ask the participants the questions they have previously determined about the subject. Going beyond the scope of the determined questions is not allowed in this method. Open-ended questions are rarely used (Yıldırım & Şimşek, 2016).

The questions used in the research were adapted to the study by benefiting from the study conducted by Aytar, Soy and Botsalı (2022). The data collection process started on July 12, 2023, in accordance with the ethics committee permission received from Karamanoğlu MehmetBey University Social Sciences Institute and ended on August 12, 2023. In the research, participants were primarily asked about demographic information such as age, education level, company sector and work experience. Then, 5 questions were asked about digitalization. One of these questions was not included in the analysis because the answers given were not satisfactory. The research questions are as follows:

Q1: Which concepts/technology/tools can you associate with the concept of digital transformation?

Q2: What contributions/benefits do you think digital transformation will have to your business?

Q3: Which processes do you think the digital transformation process has the potential to affect most in your business?

Q4: Which asset/resource do you rely on most in your business to achieve digital transformation?

Q5: Is there a business group, magazine, website or platform from which you obtain information about digital transformation? If so, can you provide information?

Analysis of Data

Content analysis method was used to analyze the research data. Content analysis, as a technique, involves special procedures. It can be separated from the personal authority of the researcher. As a research technique, content analysis is a scientific tool that

increases a researcher's understanding of certain phenomena, provides new perspectives, or informs practical actions (Krippendorff, 2018). In the study, first the demographic data of the participants were examined and the information obtained is presented in Table 1. Then, the data obtained from the questions about digitalization asked to the participants in the interviews were analyzed through MAXQDA software.

Findings

In the study, firstly, the demographic information of the participants was examined. Information about the age, education level, total work experience and company sector of the 11 people who participated in the research are shown in Table 1.

Table 1: Demographic Information of Participants

P	Age	Education	Sector	Experience
P1	43	Bachelor Degree	Defense Industry	15 Years
P2	56	PhD Graduate	Health	33 Years
P3	29	Master's Degree	Advertising	6 Years
P4	32	Master's Degree	Marketing	7 Years
P5	38	Master's Degree	Industrial	15 Years
P6	24	Master's Degree	Technology	2 Years
P7	29	Master's Degree	Technology	7 Years
P8	40	Master's Degree	Technology	20 Years
P9	28	Bachelor Degree	Consultancy	3 Years
P10	27	Master's Degree	Finance	7 Years
P11	40	PhD Graduate	Education	15 Years

As seen in Table 1, the average age of the participants was determined as 34.45. The average of their total work experience was calculated as 11.45 years. Those working in the technology sector are among the 27.3%. Other sectors include the Defense Industry, Health, Advertising, Marketing, Industrial, Consultancy, Finance and Education sectors, respectively. It was determined that 18.2% of

the participants had a bachelor's degree, 63.6% had a master's degree, and 18.2% had a doctorate degree.

After examining the demographic information, word trends and word cloud analyzes were applied to the participants' answers to the first five questions in the interviews with MAXQDA software, and the obtained data were expressed with the help of figures.

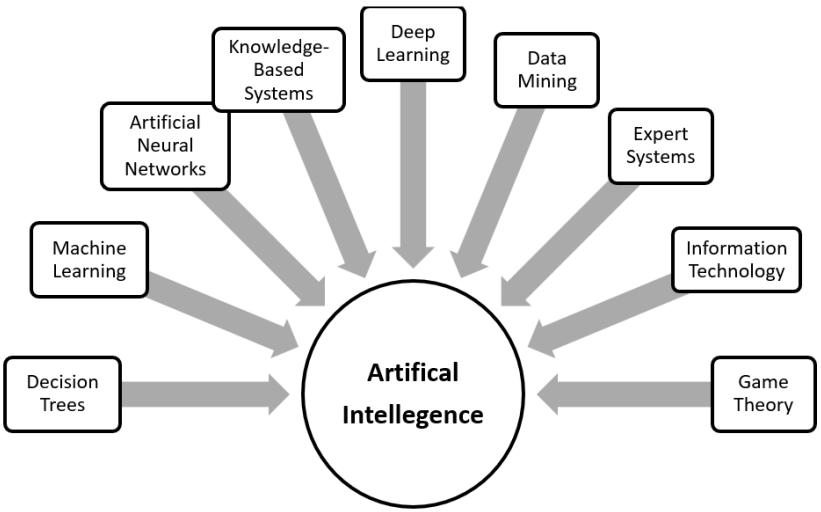

Figure 1: Artificial Intelligence and Related Concepts

What concepts/technology/tools can you associate with the concept of digital transformation addressed to the participants? When the findings obtained as a result of the in-depth analysis of the answers to the question are analyzed with a holistic approach, in general, it was observed that the participants' awareness of digitalization was high enough to establish relationships with many concepts. As shown in Figure 1, it was revealed that team leaders particularly emphasized the concept of artificial intelligence. The

figure displays the common concepts used by the participants when expressing their views on artificial intelligence. In addition, it has been understood that the theoretical knowledge base on the concept of digital transformation has gradually begun to be established among leaders in private enterprises. Artificial intelligence machines do not yet have emotional intelligence. Therefore, AI leadership needs to reconsider the current influences used to direct people and take steps to adapt to them (Smith & Green, 2018).

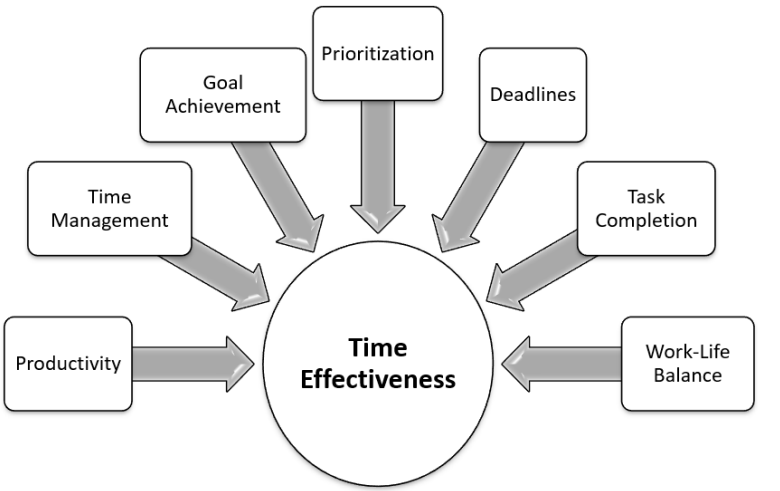

Figure 2: Time Effectiveness and Related Concepts

What kind of contributions/benefits do you think participants will have from digital transformation to your business? When the findings obtained as a result of the in-depth analysis of their answers to the question are analyzed with a holistic approach, it has been revealed that digital transformation provides businesses with advantages such as data management, time and labor savings, reduction in costs, efficiency and income increase. As shown in Figure 2, it was observed that team leaders particularly focused on

the effective use of time. The figure displays the common concepts used by the participants when expressing their views on time effectiveness. In addition, it has been revealed that team leaders working in private businesses have been trying to adapt digital transformation practices that minimize the margin of error and risk to companies for a long time. Leaders realize that they cannot be everywhere at once. Leaders must be able to allocate their time appropriately in order to be in the right place at the right time (Notar, Uline & KingEady, 2014).

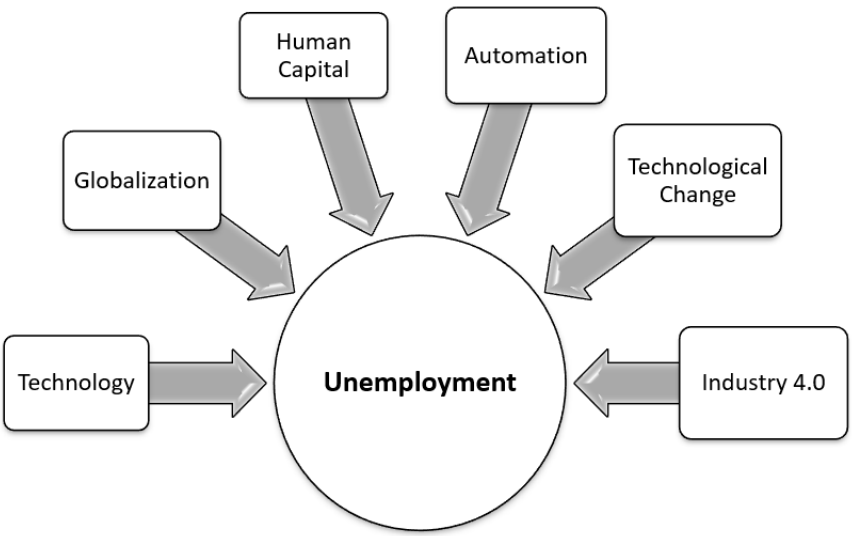

Figure 3: Unemployment and Related Concepts

Participants were asked: "Which processes do you think the digital transformation process has the most potential to affect in your business?" When the findings obtained as a result of in-depth analysis of the answers to the question are analyzed with a holistic approach, it has been revealed that digital transformation will bring

about significant changes in human resources management, project management and time management processes in businesses. This is an indication that operational processes will be carried out much faster and more efficiently in the coming years. As seen in Figure 3, it is thought that team leaders particularly emphasize the concept of unemployment and that digitalization will destroy many lines of business. The figure displays the common concepts used by the participants when expressing their views on unemployment. One industrial robot can directly replace 5.6 to 6.2 manufacturing workers in the United States. The increase in industrial robot stocks between 2010 and 2030 will be equivalent to the additional labor supply of 57 to 64 million workers. Ultimately, the number of jobs that need to be created to reach targeted unemployment rates between 2010 and 2030 is between 791 and 798 million (Bloom, McKenna, & Prettner, 2018).

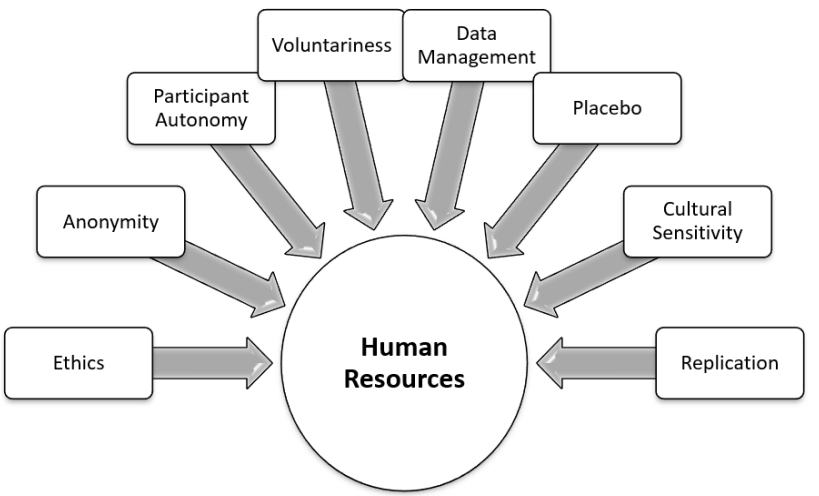

Figure 4: Human Resources and Related Concepts

"Which asset/resource do you trust most in your business to achieve the digital transformation directed to the participants?" When the findings obtained as a result of in-depth analysis of the answers to the question are analyzed with a holistic approach, as seen in Figure 4, it is understood that team leaders trust human resources the most in achieving digital transformation. The figure displays the common concepts used by the participants when expressing their views human resources. It has also been revealed that many businesses have increased their investments in the technologies required for digital transformation by establishing a strong IT infrastructure. There have been significant changes in HRM processes that continue today. Recruitment processes have changed under the influence of digital platforms, international connections, globalization, social networks and many other factors. The concepts of education and digital communication have shown their importance even in crises such as pandemics (Lumi, 2020).

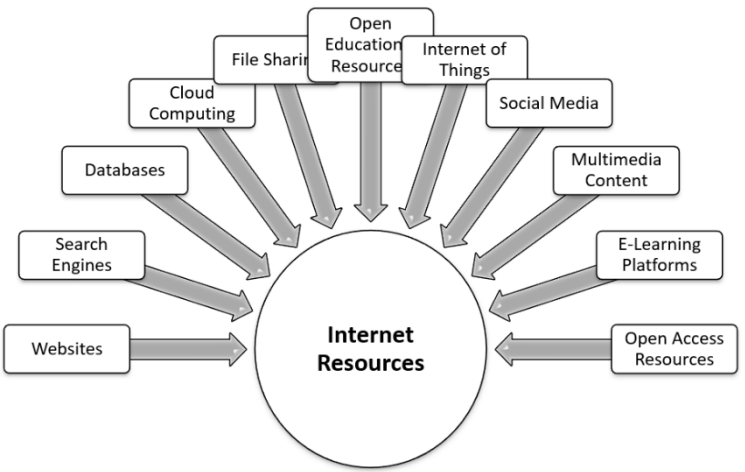

Figure 5: Internet Resources and Related Concepts

Finally, “Is there a business group, magazine, website or platform from which you obtain information about digital transformation? If so, can you provide information?” When the findings obtained as a result of the in-depth analysis of the answers to the question are analyzed with a holistic approach, it has been revealed that the majority of team leaders are insufficient to improve themselves in the field of digitalization or the company they work for does not provide them with support in this regard. As seen in Figure 5, leaders who stated that they follow the latest developments in the field of digitalization generally mentioned that they benefit from internet resources. The figure displays the common concepts used by the participants when expressing their views on internet sources. Although some leaders say that they benefit from the resources of their own businesses, it has become clear that companies need to provide training to their employees on digitalization and obtain subscriptions to magazines that publish on these subjects. Corporate websites are excellent channels for sending signals regarding the level of digitalization, as they provide leaders with rapidly updated information at a low cost (Salvi et al., 2021).

Table 2: Determined theme and content concepts

Team Leaders (P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11)				
Arifical Intellegence	**Time effectiveness**	**Unemployment**	**Human Research**	**Internet resources**
Decision Trees, Machine Learning, Artificial Neural Networks, Knowledge-Based Systems, Deep Learning, Data Mining, Expert Systems, Game Theory	Productivity, Time Management, Goal Achievement, Prioritization, Deadlines, Work-Life Balance, Task Completion	Technology, Globalization, Human Capital, Automation, Technological Change, Industry 4.0	Ethics, Anonymity, Participant Autonomy, Voluntariness, Data Management, Placebo, Cultural Sensitivity, Replication,	Websites, Search Engines, Databases, Cloud Computing, Open Access Resources, E-Learning Platforms, Multimedia Content, Social Media, Open Educational Resources, Internet of Things (IoT), File Sharing

Source: Authors

Team leaders clearly understand the strategic importance of digital transformation for their organizations. The concepts associated with the themes align with previous academic studies (Balakrishnan, & Das, 2020; Jedynak et al., 2021; Gong & Ribiere, 2021; Kraus et al., 2021). Table 2 presents the collective themes and concepts identified in the study. The concepts used also reveal that digital transformation is an artificial intelligence-oriented and internet-based development process. Although the participant team leaders stated that they were aware of digital transformation, the data contents obtained are remarkable.

Discussion and Conclusion

Rumors that artificial intelligence and smart robots will replace human power have been on the agenda for a long time. With the increase in digitalization, many businesses have started to focus on technological investments. Thanks to these investments made with long-term considerations, it has become possible to encounter developments such as decreasing the costs allocated to human resources in the coming years and leaving jobs that do not need to be done by human power to robots. With the spread of cloud computing, businesses will get rid of extra costs such as document storage and paper consumption and will start storing data electronically. In addition, communication between staff will be carried out with the help of established virtual networks. The idea that dark factories established thanks to concepts such as big data and the internet of things will be able to carry out production operations alone in the coming years has gradually begun to cease to be a science-fiction scenario.

The rapid spread of digital transformation in the world brings to mind the question of whether people will lose their jobs. Leaving the control of production processes to artificial intelligence poses a danger to the future of humankind. The fact that artificial intelligence and robots lack human emotions increases the concern that businesses will become completely profit-oriented institutions. Although digital transformation has many benefits for businesses, the final decision-maker must be human. Leaders, who are the people who have the final say in businesses, have great responsibilities in this regard. Team leaders need to have the necessary equipment and constantly renew themselves to prepare

businesses for digital transformation and to adapt to the times during this preparation.

This study aimed to investigate team leaders' awareness levels about the digitalization process. For this purpose, online interviews were conducted with 11 team leaders who are team leaders in the private sector in Turkey. First of all, demographic questions were asked to the participants, including age, work experience, sector of the company they work for and education levels. Then, 5 fully structured questions were asked to measure the team leaders' digitalization awareness levels. The obtained data were analyzed with MAXQDA software.

When the answers given to the questions asked to the leaders in the research were examined in general, it was determined that the digitalization awareness of the team leaders was high. According to the answers given, it has been understood that digital transformation activities have already started to be implemented in many sectors in Turkey and investments have been made in this direction. Due to the innovations brought by digitalization, it has become necessary for business team leaders to develop new strategies in order to keep up with the times. It has been understood that team leaders agree that many units in businesses will be transformed by the impact of digitalization. It is seen that the most trusted resources in realizing digital transformation include personnel, financial resources and IT infrastructure. Apart from these, it has been revealed that although the theoretical background of team leaders is sufficient, they are weak in following innovations in digitalization. In this regard, it has been understood that companies should train both their leaders and other personnel on digitalization and carry out activities to increase

access to magazines, books or internet resources that enable current developments in digitalization to be followed.

When previous studies in the literature were examined, in the study conducted by Nell et al. (2021), a survey was applied to 160 senior managers in Europe to investigate the effects of digital transformation on leaders and solutions were offered for the difficulties that team leaders will face in digitalization. In the study conducted by Gjellebæk et al. (2020), group-focused interviews were conducted with mid-level managers to investigate the difficulties faced by team leaders in e-health applications and it was recommended that team leaders use learning-oriented and adaptive leadership. In the study conducted by Wrede, Velamuri and Dauth (2020), interviews were conducted with 27 senior managers in German companies to investigate the actions of senior team leaders that facilitate digital transformation, and it was emphasized that team leaders understand digital change, determine the formal context for digital change, and lead the change. In the study conducted by Yorulmaz and Patruna (2021), the interview method was used to examine the opinions of team leaders in port enterprises about digitalization, and it was revealed that port team leaders were cautious about digital transformation. In the study conducted by Ekşili and Çelik Çaylak (2022), a phenomenological study was conducted with 124 managers in the tourism sector in order to determine the perspectives of team leaders working in the tourism sector on digitalization, and it was understood that the majority of team leaders viewed digitalization positively. In the study conducted by Kaya and Gemlik (2021), a focus group meeting was held with 7 hospital managers to learn the opinions of hospital team leaders about digitalization and it was determined that they had generally

positive opinions. What distinguishes our research from studies in the domestic literature is that it has expanded the scope by conducting a study on leaders working in the private sector throughout Turkey, regardless of sector. The limited number of studies on the subject in the domestic and foreign literature also makes our research meaningful.

The limitations of our research include the fact that only 11 leaders could be reached due to insufficient time. In addition, since the leader profiles suitable for the sample of our research live in cities such as Ankara and Istanbul, the difficulty in reaching them constitutes our other limitation. In the future, it may be considered to conduct more comprehensive studies by reaching more leaders and sectors.

As a result, the effects of digitalization on businesses are felt more and more every day. In order to keep up with the times, businesses are accelerating technological investments and training their personnel on this subject. In order to realize digital transformation, team leaders must be willing and produce strategies on this issue. In addition, team leaders need to follow current developments and constantly renew themselves in order to improve themselves in this field. Otherwise, it does not seem possible for businesses that cannot realize the transformations required by the age to survive.

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CHAPTER II

Sustainability in Maritime Management: The Transition to Alternative Fuels and Emission Reduction Strategies

Cihat AŞAN[1]

1.Introduction

Maritime trade has played a significant role in the global economy, facilitating the transportation of over 80% of global trade in terms of volume and 70% in terms of value. However, as maritime transportation grows, it faces challenges such as air pollution and greenhouse gas emissions. Heavy fuel oil (HFO) has become the primary fuel type due to its availability and lower cost, but it contains elevated levels of mineral pollutants, such as sulfur, vanadium, and nickel, which cause harm to the atmosphere and lead to air pollution.

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GHG emissions, including carbon dioxide (CO_2), methane, nitrous oxide, and water vapor, are also a major concern. The International Maritime Organization (IMO) has implemented stricter regulations concerning global maritime industry operations, aiming for a preliminary reduction of 50% in greenhouse gas emissions by 2050 (Christodoulou and Cullinane 2022). Companies are working to find ways to reduce emissions and mitigate the effects of air pollution from ship-source emissions.

This qualitative study aims to guide companies in the transition to alternative fuels and emission reduction strategies. It analyzes the literature to provide a general outlook on the current situation of transitioning to alternative fuels and emission reduction strategies. By 30 years, alternative fuels will become more available and convenient in terms of cost, enabling companies to achieve the zero-emission goal.

2.Literature Review

The literature on the transition to alternative fuels and emission reduction strategies highlights the importance of conserving the marine environment. With the wide spread of alternative fuel options, it seems possible to minimize the harm of maritime-sourced pollution. Some studies have examined alternative fuels for marine diesel engines, such as hydrogen, which has the potential to serve as an alternative to liquefied natural gas for ship fuel. However, further studies and enhancements are needed to address compliance with emission regulations and assess the impact on engine components.

Al-Enazi et al. (2021) investigate the feasibility of using various clean fuels in maritime applications, focusing on

environmental, economic, and technical aspects. This study supports the expectation that there will be a continuous increase in demand for alternative fuels as the maritime industry increasingly adopts cleaner fuel options to adhere to escalating environmental regulations.

Christodoulou and Cullinane (2022) analyze the EU's Monitoring, Reporting, Verification (MRV) database to assess the fuel types utilized, fuel consumption, and CO_2 emissions of ships operating within the European Economic Area (EEA) during 2020. This research offers crucial insights to maritime stakeholders and policymakers regarding the potential implications of the initiative for adopting cleaner marine fuels and the maritime sector's role in achieving a climate-neutral Europe by 2050.

Kouzelis et. al. (2022) identify bio-oil, Fischer–Tropsch diesel, and liquefied bio-methane as the most suitable alternative maritime fuels for the future. Moshiul et. al. (2023) use a decision-support tool to address the selection of alternative fuel challenges in international shipping, revealing that crucial criteria for optimal alternative selection include technological aspects, technology status, expenditures, ecosystem impact, and health-safety considerations.

Harahap et al. (2023) explore the potential of producing renewable and low-carbon fuels for the maritime industry, focusing on Sweden as a case study. They use techno-economic modelling studies to investigate factors, possibilities, and drawbacks associated with decarbonizing the shipping industry.

Wang and Wright (2021) explore the fundamental and expanded responsibilities and cooperations within the value chain

related to the implementation of Sustainability Development Goals (SDGs) in the maritime industry.

Balcombe et al. (2019) evaluate the alternatives and their collective capacity to decarbonize global shipping, considering technological, environmental, and policy aspects. Dos Santos, et. al. (2022) evaluate primary publications on the Web of Science database to pinpoint cleaner alternative fuels serving as decarbonization options in the maritime industry. The findings indicate substantial growth in the field, with a growth rate of 15.8%, and significant contributions emerging predominantly from the USA. LNG stands out as the most extensively researched alternative fuel, but recent trends indicate a shift in researchers' focus on methanol, ammonia, and hydrogen fuels.

Wang and Notteboom (2014) undertake a systematic review to merge the results from 33 published studies on the use of LNG as a ship fuel. Their study aims to achieve a more comprehensive understanding of the current viewpoints and challenges in using LNG as a bunker for ship propulsion and identify the deficiencies and limitations in the literature that could steer future research.

3.Implementation of Sustainability in the Maritime Industry

The inception of the initial Industrial Revolution coincided with the invention of the steam engine. Presently, the industry has progressed through more than four technological and social revolutions, fundamentally altering industrial paradigms and operational methodologies. As seen in Table 1 the chronological progression, characteristics, and potential economic ramifications of past, present, and anticipated future industrial revolutions on both

the industry and the workforce can be observed (Shahbakhsh et al., 2022).

Table 1: Timeline of the Industrial Revolution (Shahbakhsh et al., 2022).

Industrial Revolution	Timeline	Feature	Economic progress
Industry 1.0	Late 18th - Early19th	Mechanize production, steam engine	Economy 1.0 (the capability of labours and physical fitness)
Industry 2.0	Late 19th -Early 20th	Mass production (Ford's production line), electricity, assembly lines	Economy 2.0 (improving working process through energy resources)
Industry 3.0	Second half of 20th	Information age (computers), automated product	Economy 3.0 (developing performance through fast exchange of information and communication network)
Industry 4.0	Early 21st	ICT Technology, cyber-physical system, Internet of Things, networking	Economy 4.0 (unprecedented change era because of innovative knowledge)
Industry 5.0	Future	Human-robot co-operation, high level of personalisation concept	Economy 5.0 (creating value through competitiveness, creativity, and innovation)

The Industry 4.0 digital revolution has significantly impacted the maritime industry, introducing intelligent and autonomous shipping solutions. The integration of IoT, Digital Twin, Big Data,

Artificial Intelligence, Cloud Computing, and automation technologies has led to a profound transformation. Machine-Type Communication (MTC) plays a crucial role in facilitating communication between vessels and shore, providing accurate position data, weather updates, and other information for search and rescue operations. IoT also helps in acquiring meteorological and oceanographic information, enabling the monitoring and preservation of the sea. Digital Twins are recognized as a critical component for gaining an economic and competitive edge in the era of Industry 4.0. The implementation of Digital Twin in the marine industry can be seen in Figure 1.

Figure 1: *Trail of Digital Twin in the Maritime Industry (Madusanka et al., 2023).*

Digital Twin (DT) technology is being utilized in various sectors in maritime affairs, such as; surface vessels, underwater vehicles, offshore platforms, and coastal power plants. Its potential applications include environmental protection, deep-sea mining, marine engineering, marine information services, environmental protection initiatives, marine energy development, marine pharmaceuticals, seawater desalination, and marine area exploitation, as seen in Figure 2.

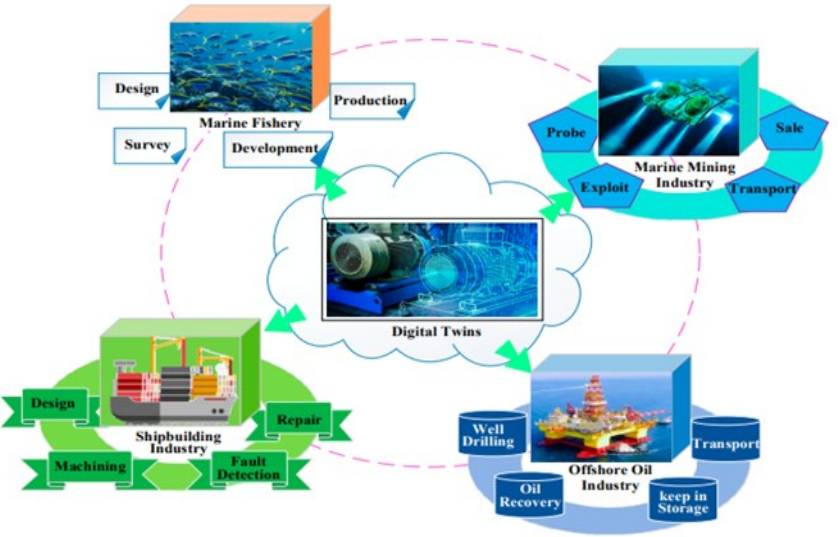

Figure 2: *Scheme of Maritime Industry with Digital Twin (Lv et al., 2023).*

4.Environmental Sustainability

Environmental sustainability is crucial in corporate business, especially in the marine industry, to preserve global life-support systems. Marine legislation targeting SOx and NOx emissions has increased interest in non-conventional marine fuels like LSHFO, LNG, LPG, and methanol. Emerging alternative fuels like carbon-neutral biofuels and zero-carbon synthetic fuels like ammonia and hydrogen are expected to become the main options for maritime companies in the next three decades.

The maritime sector consumes approximately 2.2 million barrels of oil equivalent, constituting about 3% of global emissions. Low-quality bunker fuel significantly contributes to emissions of sulfur oxide (SOx), nitrogen oxide (NOx), and particulate matter (PM). Transitioning to alternative fuels and achieving zero carbon

emissions in maritime shipping have gained support (Al-Enazi et al., 2021).

Wind-Assisted Ship Propulsion (WASP) is a sustainable maritime technology that uses wind power to replace fossil fuel propulsion, resulting in fuel savings of 2.6% to 22%. This technology enhances operational security, increases asset profitability, and serves as a safety measure against volatile fuel prices. Despite limited adoption in the global commercial maritime fleet, WASP is gaining traction Chou(Chou et al., 2021).

4.1.Factors Affecting Marine Environmental Sustainability

Marine environmental sustainability is influenced by four main factors: air pollution, ballast water pollution, overexploitation, and climate change. Air pollution, primarily from maritime transport, affects human health, environment, and contributes to global warming. The shipping sector is concerned about the introduction of invasive species into new environments, and open ocean exchange is suggested as a strategy to limit this. Overexploitation, a global environmental issue, poses risks to human food security and marine biodiversity. Fish, a major source of animal protein, is depleted, contributing to habitat destruction and decreasing species diversity. This issue is particularly concerning in the deep ocean, where oil and gas exploration and fishing pressures pose significant threats. Climate change indirectly impacts maritime activities in coastal communities, increasing the likelihood of marine pollution and harming the marine environment. National security concerns, such as power projection and territorial defense, are also affected by climate change. Environmental security concerns include marine pollution, environmental health, and marine pollution.

Understanding how climate change affects marine ecosystems is crucial for understanding their continued provision of benefits, such as tourism, which serves as a significant income source for some coastal areas (Brennan & Germond, 2024); (Kopela, 2017); (Coleman & Williams, 2002)

4.2.Regulations on Marine Environmental Sustainability

Maritime transportation, a cost-effective and efficient mode of transportation, has been significantly impacted by industrialization and globalization. However, seas have become increasingly polluted due to vessel emissions, posing significant environmental challenges. The international community has implemented regulations to mitigate ship-related pollution, including the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI and the Monitoring, Reporting, and Verification (MRV) system. These regulations aim to ensure safety, enhance navigational efficiency, and protect the marine environment (Yang et al., 2020).

The Marine Environment Pollution Committee (MEPC) is responsible for drafting regulations. MARPOL Annex VI, developed by the International Maritime Organization (IMO), aims to prevent marine sea pollution. The Air Pollution Conference of 1997 adopted a new Annex VI, "Regulations for the Prevention of Air Pollution from Ships," which entered into force in May 2005. The agreement is continually updated to reduce the environmental impact of the shipping industry, improving air quality in seas and coastal areas and ensuring environmental sustainability. The Monitoring, Reporting, and Verification (MRV) system is crucial in evaluating greenhouse gas emissions in the maritime sector and helps guide regulatory

advancements at regional and global scales. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) established the legal framework for maritime security regimes, defining state sovereignty, rights, and obligations regarding ocean space and resources. Ballast Water Management (BWM) regulates marine pollution, with two main programs for managing ballast water: the Ballast Water Exchange Standard and the Ballast Water Performance Standard (Singh et al., 2016); (Werschkun et al., 2014).

5.The Global Impact of Marine Fuels Used in Maritime Transportation in the Aspect of Air Pollution

Marine transportation's environmental impact is complex, involving causes, operational activities, emissions, and impacts. It interacts with environmental cycles, contributing to degradation. Air pollution is the primary environmental externality, with shipping emissions accounting for 4-5% of global emissions. Until the 1990s, there was not a commencement of efforts to assess emissions from maritime industry. This period is shared with the steady rise of SO2, NOx, CO_2, and particulate matter (PM) emissions due to the expanding international trade, which consequently drives fuel consumption (Wang et al., 2009).

5.1.Global Warming

Global warming is the rise in Earth's average temperature due to human activities like burning fossil fuels and deforestation, releasing greenhouse gases into the atmosphere. The greenhouse effect, involves greenhouse gases absorbing infrared radiation, causing higher surface temperatures (JSciTechnol & Venkataramanan, 2011). The global average temperature increase for this century is expected to be between 0.5-4.0°C, potentially

leading to sea level elevation, island submergence, and ocean acidification. Since 1900, temperatures have increased by 0.8°C, reaching their highest levels since the 19th century as seen in Figure 3 (Asariotis & Benamara, 2012).

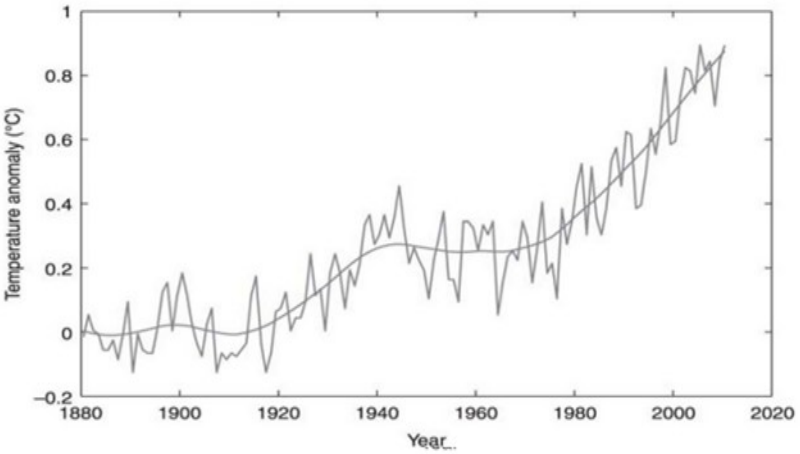

Figure 3: *Global Mean Temperature up to 2010 (Asariotis & Benamara, 2012).*

5.2.Climate Change

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as a detectable, long-lasting change in climate characteristics, affecting various aspects such as rising temperatures, extreme weather, sea levels, ecosystems, water resources, agriculture, food safety, health, and economic consequences. Recognizing these changes is crucial as greenhouse gas emissions do not immediately impact the climate.

5.3.Air Pollution

In 2015, air pollution caused 6.4 million global fatalities, contributing to 21% of cardiovascular, 25% of ischemic heart

disease, 24% of stroke, and 27% of lung cancer deaths. Primary sources include ship traffic, industrial activities, railway transportation, and residential emissions in ports and coastal regions. Increased shipping emissions due to global trade expansion contribute to air pollution, acidity, and eutrophication in European coastal environments, causing severe health issues (Mueller et al., 2011); (Čampara et al., 2018).

The maritime industry contributes to 33% of fossil fuel emissions and 3.3% of global carbon dioxide emissions. Factors like fuel type, engine specifications, and efficiency influence emissions. Over the past 50 years, emissions have increased, particularly in coastal regions, with 70% occurring within 400 km. Common air pollutants include nitrogen oxides, volatile organic compounds, carbon monoxide, and particulate matter. The maritime industry contributes 10%-15% to anthropogenic SOx and NOx emissions, with shipping bunker fuel containing 27,000ppm sulfur, leading to smog, ocean acidity, and respiratory problems (Viana et al., 2014); (Walker et al., 2018).

6.The Present Implementations of Transitioning to Alternative Fuels and Emission Reduction Strategies

Marine fuels are evolving due to technological advancements and environmental concerns. Traditional options like marine gas oil, diesel oil, and heavy fuel oil are being replaced by cleaner alternatives like biofuels, low-sulfur fuels, and liquefied natural gas. These alternatives offer varying levels of emissions, efficiency, and environmental impact, allowing ship operators to choose the most suitable option (Bengtsson et al., 2011).

Economic and population growth are driving global energy demand, leading to an expansion in international maritime trade and a rise in global shipping vessel fleet size. The maritime sector facilitates 80-90% of global trade and transports over 10 billion tonnes of bulk cargo annually (Ampah et al., 2021). Around 52,000 merchant vessels transport goods and passengers globally, with a combined engine capacity exceeding 500 GW. These vessels surpass Europe's fossil-fuel power stations but lack universally applicable decarbonization solutions due to their diverse services, vessel types, fuel types, emissions, and regulatory frameworks. The international maritime industry contributed 3.1% of the world's CO_2 emissions in 2018, but between 2007 and 2018, the proportion of shipping emissions decreased due to growth in non-shipping emissions, particularly from China and India's coal-fired electricity generation. The marine industry, particularly oil tankers, bulk carriers, and container ships, are major sources of greenhouse gas emissions due to their long journeys across continents and globally. These emissions are spread throughout most of the northern hemisphere's oceans and seas as illustrated in Figure 4. The fuel used and vessel operational effectiveness also influences shipping emissions, with different fuels emitting varying amounts of CO_2, SOx, NOx, and methane (Balcombe et al., 2019).

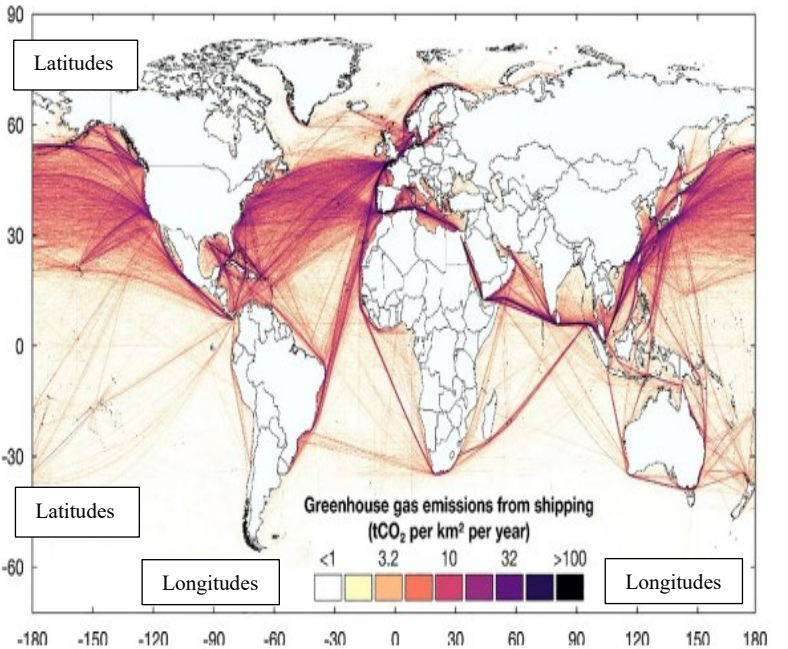

Figure 4: *Ship-Sourced Greenhouse Gas Emissions Distribution Chart (Balcombe et al., 2019).*

Heavy fuel oil (HFO) accounted for 72% of global maritime fuel consumption in 2018, with only 2% coming from LNG and 26% from marine diesel oil. HFO's high sulfur content contributed to 13% of global SOx emissions in 2016, causing soil and water acidity, harming ecosystems, and posing health risks. Although shipping emissions have a short-term cooling effect, long-term greenhouse gas emissions are expected (Balcombe et al., 2019).

The maritime industry, which saw an 18% growth in global trade by 2019, is heavily reliant on fossil fuels, particularly Heavy Fuel Oil (HFO). In 2018, the sector generated over one million tonnes of CO_2 and greenhouse gas emissions, a 9.6% and 9.3% increase from 2012. The International Maritime Organization (IMO)

warned in 2014 that global trade growth would lead to a 50% to 250% increase in shipping emissions by 2050, with 15% of global CO_2 emissions coming from marine transport. The IMO aims for complete decarbonization of the maritime transportation sector, with goals for a minimum 50% reduction by 2050 and a 40% decrease by 2030 (Ampah et al., 2021).

The International Maritime Organization (IMO) has set regulations to reduce greenhouse gas emissions from ships, with the main goal of reducing global shipping's carbon intensity by 70% and total annual emissions by at least 50% by 2050 (Christodoulou & Cullinane, 2022). Low-sulfur heavy fuel oil, marine diesel oil, marine gas oil, and equivalent exhaust gas cleaning systems (EGCS) have been widely used to manage SOx emissions. Liquefied natural gas (LNG), mainly methane, liquefied petroleum gas (LPG), predominantly propane and butane, and methanol have emerged as primary options to meet IMO NOx emissions standards.

MARPOL Annex VI introduced the Energy Efficiency Design Index and Ship Energy Efficiency Management Plans to improve vessel energy efficiency and reduce CO_2 emissions. However, current measures are not meeting the Initial IMO Strategy's goals. Alternative marine fuels like LNG, methanol, biofuels, hydrogen, and ammonia are identified as potential solutions.

Several studies have evaluated alternative marine fuel options using decision-making methodologies. Qualitative assessments were used to compare the life-cycle environmental impacts of various fuels, including HFO, MGO, biomass to liquid (BtL) fuel, rapeseed methyl ester, LNG, and LBG for short-sea

shipping. LNG demonstrated the lowest local and regional environmental impact, while LBG had the lowest overall impact. A life-cycle assessment was conducted on LNG, methanol, LH2, biodiesel, and straight vegetable oil, considering potential biomass sources and carbon capture and storage technology. However, no definitive selection of alternative marine fuels was proposed for future shipping, providing insights for further research. Quantitative evaluation methods like multi-criteria decision analysis and analytical hierarchy process were employed to assess the sustainability of LNG, methanol, and hydrogen. Sustainability rankings placed hydrogen first, followed by LNG and methanol. A technological comparison of alternative marine fuels revealed LNG as the most suitable option, with methanol and ethanol ranking lower due to limited availability (Xing et al., 2021).

6.1.Transitioning to Alternative Fuels

The United Nations and the International Maritime Organization (IMO) have pledged to increase efforts to reduce greenhouse gas emissions from international shipping, aligning with the Paris Agreement's goals, as part of the 2030 Agenda for Sustainable Development. The IMO's Initial Strategy outlines short-term, mid-term, and long-term measures with suggested timelines, as shown in Table 2.

***Table 1**: Strategies and Measures that Categorized as Short-term, Mid-term and Long-term (Ampah et al., 2021).*

	Short-term	Medium-term	Long-term
Timeline	2018–2023	2023–2030	Beyond 2030
Measures	• Improve energy efficiency framework • Develop technical and operational energy efficiency measures • Encourage national policies, incentives, and port activities • Initiate research on alternative fuels and innovative technologies • Undertake additional GHG emission studies	• Implement program for the effective uptake of alternative fuel • Operational energy efficiency measures • Innovative emission reduction mechanism • Enhance technical cooperation • Develop feedback mechanism to learn and share lessons learned	• Pursue the development and provision of alternative fuels • Encourage and facilitate the general adoption of other possible innovative emission reduction mechanisms

To improve logistics chains and port operations, research and development initiatives should focus on introducing zero-carbon and low-carbon fuels and innovative technologies to enhance maritime energy efficiency before 2023. Governments and ship owners should invest in vessel solutions to achieve short-term GHG reductions and improve air quality, contributing to the long-term sustainability of the shipping industry and preserving global trade advantages. Short-

term approaches include bio-based marine fuels and scrubbers, while mid-term objectives involve assessing the commercial and operational viability of alternative fuels, updating national action plans, and enhancing energy efficiency in existing vessels (Ampah et al., 2021).

Developed nations are increasingly interested in clean fuels as a substitute for traditional fossil fuels, driven by their commitment to international organizations to combat global warming. The 2015 United Nations Climate Change Conference (COP 21) saw numerous countries signing agreements aiming to limit global temperature increase to below 2°C above pre-industrial levels. However, countries with abundant hydrocarbon resources have been slower to adopt clean fuels (Al-Enazi et al., 2021).

Future fuels will need to lower emissions below regulations to replace heavy fuel oil and marine diesel oil. Emission Control Areas (ECAs) consume 30-50 million tons annually, and adopting alternative, low-carbon fuels can effectively fulfill the need for low-sulfur fuels and reduce greenhouse gas emissions. Current alternatives include electricity, biodiesel, methanol, LNG, LPG, DME, biomethane, synthetic fuels, hydrogen, HDRD, and pyrolysis oil. Ultra-Low-Sulphur Diesel (ULSD) can help ease the switch to alternative fuels (Moirangthem & Baxter, 2016).

6.1.1.Ultra Low Sulphur Diesel (ULSD)

Low sulfur residual fuel (LSRF) is diesel fuel with a maximum sulfur level of 500 parts per thousand, while Ultra-Low sulphur diesel fuels (ULSDs) have extremely low sulfur content (15 ppm mass basis). ULSDs are compatible with modern fuels and are used in marine engine installations or existing ones. Since 2006,

most petroleum-based diesel fuel in North America and Europe has been ULSD. However, due to costs and rising demand, low-sulfur residual fuels are more expensive than high-sulfur residual fuels. The difference in cost between residual fuel (2.0-3.5% sulfur) and distillate (0.1-0.5%) is about USD 300 per ton for distillate (Moirangthem & Baxter, 2016).

Vessels using residual fuel must follow specific protocols for transitioning to lower-viscosity distillate fuels, requiring vigilant monitoring of gasoline tanks to prevent unregulated growth. Refineries have addressed lubrication concerns in ULSD fuel, and diesel engine manufacturers have created a "Smart Switch" to facilitate the transition.

6.1.2.Biofuels

Vegetable oils, due to their renewable nature and ease of production in rural areas, offer a promising alternative to diesel fuel. However, burning raw oils can cause engine issues like carbon particle accumulation and increased wear. Researchers suggest transesterification to produce biodiesel from monohydric alcohol and vegetable oil or animal fat, reducing greenhouse gas emissions and requiring minimal engine modifications (Al-Enazi et al., 2021).

Biofuels can significantly reduce greenhouse gas emissions by directly using them in existing engines. First-generation conventional biofuels like methanol, biomethanol, and algae biofuel face sustainability concerns due to massive production. Waste oils can partially address these issues, but their scarcity is significant. Advanced biofuels, such as Fischer-Tropsch diesel, pyrolysis oil, lignocellulosic ethanol, bio-methanol, dimethyl ether, and bio-LNG, use lower environmental risks and typically have lower GHG

emissions. These advanced biofuels are suitable for international transportation and can address sustainability concerns (Balcombe et al., 2019). Figure 5 demonstrates that advanced biofuels typically exhibit reduced greenhouse gas (GHG) emissions compared to conventional biofuels.

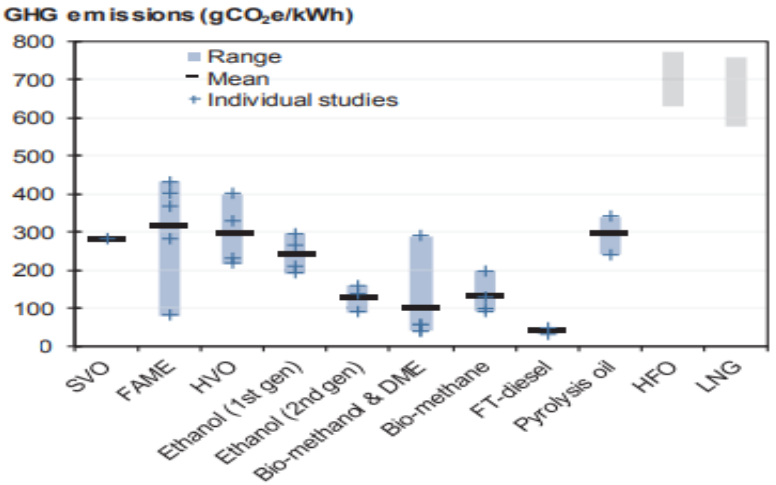

Figure 5: *Chart of the Greenhouse Gas Emissions of Each Fuel (Balcombe et al., 2019).*

Biofuels can partially meet emission reduction targets for NOX, SOX, and GHG due to their low sulfur content and organic decomposition. They can be easily introduced into existing marine diesel engines with minimal modifications. Biofuel fuels are divided into six types: methanol, biomethanol, Dimethyl Ether, Biodiesel or FAME, Hydrogen Derived Renewable Diesel, and Algae Biofuel. Methanol is the most fundamental type of alcohol and is cleaner than heavy fuel oil and marine gas oil. It can be obtained from non-renewable energy sources, biomass, and carbon-containing raw materials. Advancements in methanol production methods are needed to establish it as a competitive alternative fuel for a low-

carbon future. Table 3 provides a comparative analysis between methanol and biomethanol.

Table 3: *Comparison Between Methanol and Bio-methanol (Kołwzan & Narewski, 2013)*

	Methanol	Bio-Methanol
Purity	>99,85%	>99,85%
Feedstock	Natural gas	Crude glycerine
CO_2 reduction		77%
Capacity		200,000 mton
Sustainability		ISCC

Figure 6 shows greenhouse gas emissions from different methanol production scenarios. Black liquor can be used to produce biomethanol as a fuel in pulp and paper mills, with lower carbon footprints possible under certain conditions. Countries like Finland, Sweden, Portugal, and Spain have low electricity consumption-related emissions. Another promising approach is the direct synthesis of hydrogen via electrolysis with geothermal electricity and CO_2 from the same reservoir, which is currently being tested in Iceland (Kołwzan & Narewski, 2013).

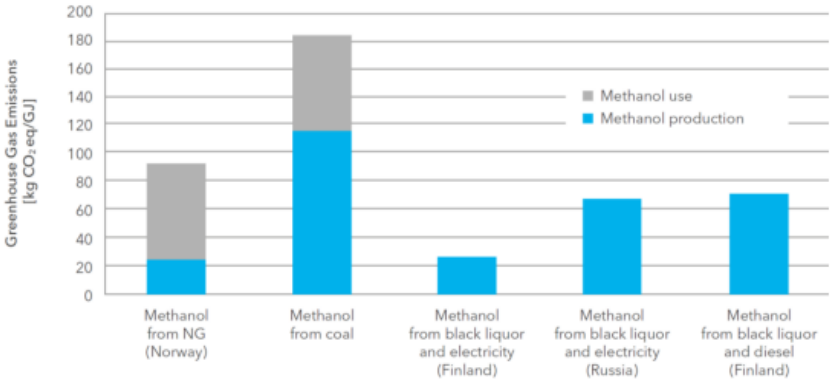

Figure 6: *Greenhouse Gas Emissions from Different Methanol Production Scenarios (Kołwzan & Narewski, 2013).*

Dimethyl ether (DME), a high-density, clean-burning liquid fuel, has gained popularity in the last two decades. Made from dehydrated methanol, it can replace diesel in heating, power generation, and transportation applications. MAN Diesel & Turbine has produced Tier-III-compatible DME engines for marine use, making it a versatile alternative to diesel fuels. DME's unique selling point is its ability to be used in compression engines (Kołwzan & Narewski, 2013). DME, a gaseous fuel similar to LPG, is used in heavy-duty vehicles and is produced through direct or indirect methods. BioDME, produced using renewable resources like biomass-derived syngas or methanol, is the most widely used. DME is being used as a direct replacement for diesel due to its better combustion, efficiency, lower auto-ignition temperature, and emissions. However, bioDME faces higher production costs, life-cycle carbon emissions, and more complex transportation and storage requirements. The current global annual production capacity is around 10 million tons, indicating a need for further progress in maritime applications (Xing et al., 2021).

Biodiesel, also known as FAME, is a biofuel produced from renewable or waste sources that can be used as a direct substitute for diesel fuel. It has chemical properties similar to regular diesel fuels but lacks sulfur and has higher free oxygen levels, allowing for thorough combustion. Biodiesel is biodegradable, non-toxic, and naturally lubricating, making it a promising option for maritime fuels. It is compatible with most diesel engine systems and requires minimal modifications. The European Academies Science Advisory Council (EASAC) has classified biodiesel into four generations based on feedstock type (Wang & Wright, 2021).

However, the technical specifications outlined in ISO 8217 enumerate future concerns regarding biodiesel or FAME as follows:

- Proneness to oxidation and issues related to prolonged storage
- Affinity to water and susceptibility to microbial growth
- Deterioration of low-temperature flow properties
- Deposition of FAME material on exposed surfaces, including filter elements.

Biodiesel, a renewable fuel, can degrade over time, causing impurities. Monitoring and testing biodiesel stored for over two months is crucial for safety. However, its sustainability concerns arise from palm oil production conflicting with rainforest preservation. Combining marine fuel with biodiesel can increase the flash point to 63°C, reducing fire risks and improving fuel safety. Biodiesel is easily accessible and comparable to marine diesel fuel prices.

Hydrogen Derived Renewable Diesel (HDRD) is a biofuel produced from fats or vegetable oils through hydrotreatment, compatible with diesel engines and fuel systems. It conforms to ASTM D 975 specifications and has similar safety characteristics to traditional diesel fuel. HDRD is recognized as an alternative fuel under the Energy Policy Act of 1992 and can be blended with petroleum diesel for maritime operations. Its production relies on existing hydro-treatment equipment, offering lower costs and superior low-temperature operability.

Algae biofuel, produced by hydrotreated renewable diesel (HRD -76), has faster growth rates than conventional crops but is expensive and impractical for commercial use. Algae diesel fuels are generally safe but have lower heating values compared to petroleum diesel. Combining algal diesel with petroleum diesel can improve performance and reduce sulfur oxide emissions. The United States Navy is the main user and innovator of algal biofuel for marine use, testing it in 2012 as part of the "Green Strike Force" program (Kołwzan & Narewski, 2013).

6.1.3.Gaseous Fuel

Just as mentioned the biofuel group under 5 subheadings, gaseous fuels are also examined under 3 subheadings. These are liquified propane gas (LPG), liquified natural gas (LNG), and biomethane - Bio LNG.

Liquified propane gas (LPG) is a promising marine fuel option, with a global market expected to grow at a 3.4% compound annual rate from 2014 to 2025. It's high-quality and affordable, suitable for automotive transportation and household heating, but its density poses an explosion hazard. Liquefied Natural Gas (LNG) is

a gas fuel that can be converted into a liquid state by chilling it below -162°C, reducing storage and transportation space by 600. It is used to comply with SOx and NOx requirements and reduce CO_2 emissions. There are four main classifications of LNG engines/turbines: lean-burn spark ignition, low-pressure dual fuel, high-pressure dual fuel, and gas turbine. LNG has been used for over forty years to reduce emissions of NOx, SOx, particulate matter, and CO_2. Natural gas has a higher ratio of hydrogen to carbon, resulting in a significant reduction of 20-30% in CO_2 emissions when burned. However, advancements in reducing CO_2 emissions may be offset by methane emissions, which are typically encountered within 2-5% of the overall throughput in LNG engines. Reducing methane emissions is essential for LNG to meet the target of reducing greenhouse gas emissions by 50% (Balcombe et al., 2019). Figure 7 shows the estimation of greenhouse gas emissions from LNG-powered ship engines.

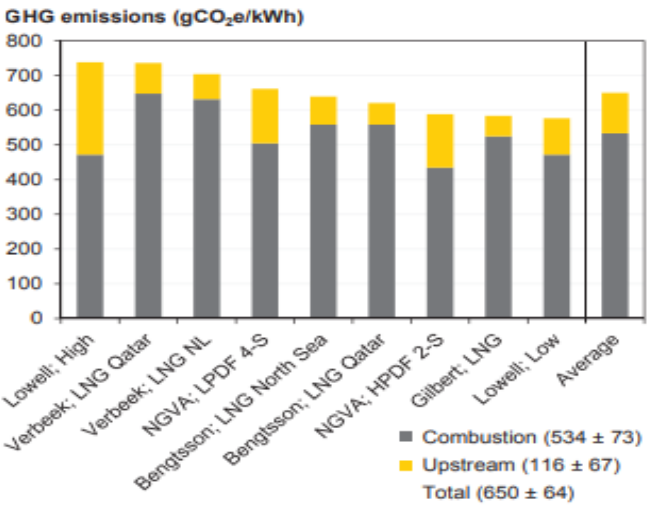

Figure 7: *Estimates of greenhouse gas emissions from LNG-powered ship engines (Balcombe et al., 2019).*

LNG eliminates sulfur emissions, reducing SOx emissions by 90-99% compared to high-pressure fuel oil (HFO). Particulate matter and NOx emissions are significantly lower in low-pressure dual-fuel engine systems. However, higher combustion temperatures lead to higher NOx levels. Some LNG engines achieve a lean fuel-to-air ratio, resulting in lower combustion temperatures and NOx reductions. NOx emissions are only observed below 30% diesel share, requiring additional exhaust gas treatment technologies.

Biomass-derived biomethane is gaining interest in the shipping industry due to its ecologically soundness and higher quality compared to fossil LNG. It can be produced through biogas enhancement or thermo-chemical conversion with lignocellulosic biomass. However, widespread adoption is limited. The European Committee for Standardization is working on a matching standard for the entire European region. Limited biogas availability could hinder widespread use of bio-LNG.

6.1.4.Shore Power and Plug-in Battery-Powered Ship (Electricity)

Shore Power (SP) is an emission mitigation technique that replaces onboard fossil fuels with energy from the shore. However, it's not entirely emission-free as electricity comes from the local power grid. Electric-powered marine watercraft began in the 1830s with the invention of a DC motor by German inventor Moritz Hermann von Jacobi. Advancements in electric propulsion have led to the use of renewable energy sources like solar photovoltaics, biomass, and wind power. Solar-powered marine vessels like the Auriga Leader project and large power plants in Rotterdam offer

better energy management, increased fuel economy, lower energy losses, and less noise and vibration (Ampah et al., 2021).

6.1.5.Pyrolysis Oil (ASTM D 7544)

Pyrolysis oil, a dark brown liquid produced by heating biomass particles without oxygen, is a potential alternative to natural gas, light fuel oil, or residual oil in various applications. It has an energy content half that of diesel, high oxygen content, and a pH of 2.5-3. Stabilization requires hydrotreatment to reduce oxygen content, requiring hydrogen. Pyrolysis oil does not auto-ignite in diesel engines and cannot be blended with diesel fuel. It is not currently approved for maritime diesel engines (Kołwzan & Narewski, 2013). Pyrolysis oil can be directly used in boilers and turbines with corrosion-resistant materials, but its use as engine fuel and for long-term storage requires upgrading, typically involving hydrogen. Recent efforts have involved upgrading pyrolysis oil for use in polygeneration and trade.

6.1.6.Hydrogen With Marine Fuel Cells

With the best energy-to-weight storage ratio of all fuels, hydrogen is the most basic and common element on Earth. Its main state is complex, though, thus extracting it requires energy. Hydrogen is produced from fossil fuels including coal, mineral oil, and natural gas as well as biomass and water. Hydrogen production uses a variety of techniques, as seen in Figure 8 (Xing et al., 2021).

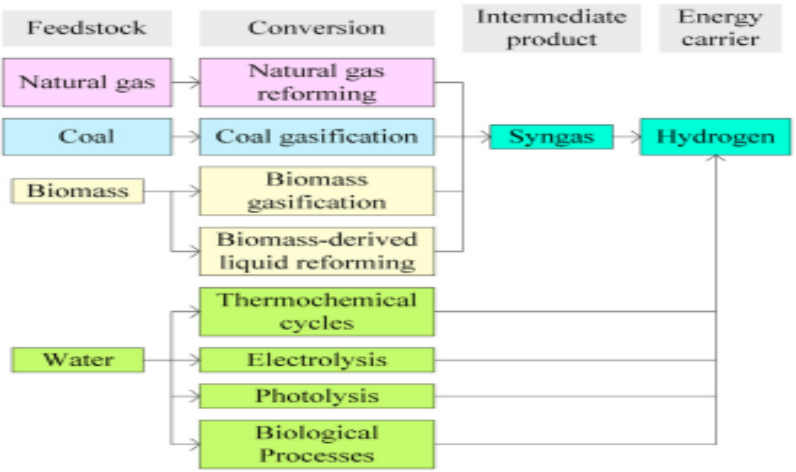

Figure 8: *Processes Schematic for Hydrogen Production (Xing et al., 2021)*

To achieve a sustainable global energy future, hydrogen fuel should be combined with other clean energy sources, including Grey Hydrogen, Blue Hydrogen, and Green Hydrogen. Grey Hydrogen emits CO_2, Blue Hydrogen uses carbon capture technology, and Green Hydrogen is generated from renewable energy sources with zero emissions (Al-Enazi et al., 2021).

Hydrogen production can be achieved through two methods: water electrolysis, which produces hydrogen without emissions, and natural gas reforming, which generates hydrogen through methane-steam reaction, resulting in CO_2 separation. While water electrolysis can be produced without emissions, it's a significant source of emissions for a standard electricity grid mix (Kołwzan & Narewski, 2013). Fuel cells are a cost-effective and environmentally friendly power source, but they require significant infrastructure investment and system planning. The emissions from hydrogen fuel cells depend on the feedstock used, with renewable electrolysis resulting in the

least emissions. Natural gas reforming with Carbon Capture and Storage (CCS) and without CCS lead to the highest emissions. Fuel cells produce minimal noise or vibrations, which is crucial for marine ecosystems. Electric motors have a high efficiency of over 95%, but when combined with fuel cells, they provide a significant improvement compared to conventional engines (Balcombe et al., 2019). Table 4 gives the several types of fuels in aspect of cargo volume and mass effect.

Table 4: *Varied Types of Fuels in Aspect of Cargo Volume and Mass Effect (Balcombe et al., 2019).*

Fuel	HFO	LNG	Compressed hydrogen	Liquid hydrogen
Density (kg/m^3)	1010	470	23.7	72.4
Daily fuel use (m^3)	83	203	1186	522
Fuel mass for voyage (t)	421	485	140	140
Tank volume (m^3)	417	1195	12140	3120
Mass of tanks (t)	–	450	8584	972
Containers displaced	–	96	372	180
Volume displaced (m^3)	–	3700	14340	6939
Weight displaced (t)	–	1258	4878	3123

As seen in the Table 4 liquid hydrogen requires eight times more storage space than HFO and thirty times more than compressed hydrogen. Using liquid ammonia storage reduces energy consumption and requires less low-temperature storage. Ammonia can be used in combustion engines or fuel cells. Marine-specific technologies are still being developed, but no have been released to the public yet. Progress is being made in dual-fuel engines.

6.1.7.Ammonia

Ammonia, a chemical without sulfur and carbon atoms, has potential for decarbonization in the marine industry due to its large storage and distribution infrastructure, economical transportation, and high volumetric energy density. However, building bunkering infrastructure is a major obstacle. Commercial ammonia production uses the Haber-Bosch process, but its CO_2 emissions are determined by its sources. Green ammonia's high dependence on fossil fuels presents cost issues, corrosiveness, toxicity, ignition quality, increased NOx emissions, and lack of thorough laws and regulations. Despite these challenges, recent research on ammonia's potential marine fuel application has been conducted (Ampah et al., 2021).

Table 5 provides an extensive evaluation of the benefits and drawbacks of every fuel type used in maritime transportation. Though alternative marine fuels have some benefits, biofuel-based propulsion systems frequently have unfavorable effects. These include higher fuel consumption, abrasive wear of fuel pumps and injectors, lubrication problems resulting from the oxidation of unsaturated molecules leading to piston ring adhesion.

Table 5: *Primary Advantages and Disadvantages of Alternative Marine Fuels (Ampah et al., 2021).*

Fuel	Advantages	Disadvantages
LNG	• Competitive fuel price • Available infrastructure and technologies	• Must be stored in insulated tanks • Cannot comply with 50% CO_2 reduction
Hydrogen	• Enable zero-emission (with fuel-cell) • Can be produced from electrolysis near ports	• Low energy density (50% of LNG) and large storage tanks cannibalize vessel cargo space limit application to short-range coastal vessels • Extensive flammability range imposes the need for safety mitigating measures at an added cost • Expensive CAPEX and OPEX around three times greater than LNG and viable production likely decades away • Absence of supply, bulk storage, and bunkering infrastructure.
Ammonia	• Can be used in various combustion engines as well as fuel cells • Can be stored at relatively low pressure and high temperature (liquefied ammonia)	• High toxicity imposes the need for safety mitigating measures at an added cost • Excessive high OPEX – green ammonia is up to 4x LNG cost • Absence of bunkering and bulk infrastructure along major cargo routes • Current production generates undesirable high GHG emissions.
Biofuel (methanol, HVO, etc.)	• Can be carbon neutral • Compatible with existing infrastructure and engine systems	❖ Methanol • Expensive fuel close to or higher than LSFO/MGO in today's market • Absence of bunkering infrastructure

		• Fossil fuel derived – GHG emissions similar to conventional marine fuels. ❖ HVO (advanced biodiesel) • Expensive • Extremely limited • Production capacity and bunkering availability • Quality and consistency of production varies; lack of agreed fuel standards, • High NOx and Particulate
Electricity (battery)	• Enable zero-emission • High efficiency	• Prohibitive CAPEX costs; battery technology not practicable for large ocean- going ships, battery costs could exceed newbuild cost of a vessel • Applicability - limited to short-range low-power coastal vessels

Nanoparticles are increasingly being used as fuel additives in on-road engines due to their unique thermodynamic properties. These properties enhance combustion, making them suitable for applications like heat transmission, emission reduction, and catalytic activity enhancement. However, to create a functional nanofuel, it's essential to evenly distribute nanoparticles throughout the main fuel while preventing them from sticking together or settling in fuel storage.

Various types of nanoparticles, such as Aluminum Oxide (Al2O3), Zinc Oxide (ZnO), Cerium Dioxide (CeO2), Iron Oxide (γ-Fe2O3), Titanium Oxide (TiO2), and Copper Oxide (CuO), are employed for consistent dispersion and long-term stability. Biofuels can also be used as additives to improve engine qualities, emissions, performance, and combustion characteristics (Ampah et al., 2021).

Alternative marine fuels pose environmental risks, including local pollutants and toxicity. Safety precautions for transporting and bunkering marine petroleum depend on the risk level. Low Sulfur Heavy Fuel Oil (LSHFO) is the least desirable alternative due to local air quality. Electric systems can improve propulsion efficiency with batteries, but they are mainly suitable for short-distance operations and specific vessel types.

6.1.8.Solar and Wind

Wind power is being developed through various sails, including traditional and modern options like Flettner rotors, kites, soft sails, wing sails, and wind turbines. These techniques can save fuel while keeping a ship moving at full speed, especially at open sea wind speeds. Fuel savings are estimated to range from 2 to 24% for a single Flettner rotor to 1 to 32% for a towing kite to 25% for eConowind sails. However, the technology is relatively new and is expected to be widely adopted before 2030. Impediments include insufficient demonstration, safety concerns, and lack of familiarity with the technology. Several maritime companies are exploring solar assistance through hybrid sail systems, such as SkySails' kite sails and B9 Shipping's cargo carrier vessel. However, the energy obtained may only support supplementary power needs and the deterioration of solar panels in salty maritime environments poses challenges. Studies suggest that onboard solar energy generation could reduce CO_2 emissions by 0.2% to 12% and increase fuel savings by 10% to 40%. Further research is needed to determine the cost-effectiveness of these technologies (Balcombe et al., 2019).

6.2.Implementations in Aspect of Emission Reduction Strategies

Maritime transportation is the most economically efficient method for global goods movement, accounting for over four-fifths of trade volume. However, shipping emissions, including CO_2, SOx, NOx, CO, CO, VOC, and PM, contribute to climate change, acid rain, and human health risks. PM, including black carbon, is the second most potent climate forcer after CO_2, causing significant environmental issues and raising concerns about the future of global trade (Serra & Fancello, 2020).

Studies such as the Second IMO GHG Study 2009, the Technical Support for European Action to Reduce GHG Emissions from International Transport, and the Quantify project have focused on the emissions of ships and their consequences. Ship emissions, accounting for 3.3% of all CO_2 emissions, have a significant impact on anthropogenic emissions worldwide. CO_2 is the main greenhouse gas from shipping activities, having the most effect in terms of quantity and potential for global warming (Lindstad, 2013).

The Second IMO GHG Study 2009 evaluates CO_2 emissions and energy efficiency of freight transportation in all modes, including road, rail, air, and sea. Sea transportation is generally more energy-efficient than other modes. Including multiple transport modes allows for the identification of suboptimal methods, where increases in one mode may offset emission reductions in another. Comparison studies should include total emissions from the entire supply chain, including transportation, raw material sourcing, and manufacturing. This strategy would require a major reorganization

of the industrial base, motivated by UN and UNFCCC policies to mitigate climate change.

The European Standardization Unit (CEN) has created a standard for calculating and reporting greenhouse gas emissions and energy consumption in transportation services, aiming to ensure consistency and clarity in comparisons between modes and competitors, promoting accurate, reliable, and verified quantitative claims about energy use and emissions.

Table 6 presents a wide range of approaches meant to lower CO_2 emissions from vessels.

Table6: *Potential CO_2 Equivalent Emission Reductions (Buahug et. al., 2009).*

Reduction option	CO_2 reduction per ton nautical mile	Combined	Combined
Design – new ships			
Concept, speed & capability	2% to 50%	10% to 50%	25% to 75%
Hull and superstructure	2% to 20%		
Power and propulsion systems	5% to 15%		
Low-carbon fuels	5% to 15%		
Renewable energy	1% to 10%		
Exhaust gas CO_2 reduction	0%		
Operation – all ships			
Fleet management, logistics&incentive	5% to 50%	10% to 50%	
Voyage optimization	1% to 10%		
Energy management	1% to 10%		

The maritime industry's global human-caused emissions have increased to 2.9%, posing significant threats to the environment and human well-being. This is primarily due to the release of greenhouse gases, sulfur oxides, nitrogen oxides, and particulate matter from shipping operations. The industry's emissions situation contradicts global emission reduction obligations, such as those specified in the Kyoto Protocol and the Paris Agreement. During the coronavirus pandemic, particulate matter emissions decreased by 38%, but this is not a viable solution. The International Maritime Organization (IMO) and the entire marine industry have a crucial responsibility in reducing emissions. The IMO has set goals to decrease CO_2 emissions intensity by 40% by 2030 and overall greenhouse gas emissions by at least 50% by 2050, requiring a change of at least 70% of current marine fuels. Energy-saving techniques and transitioning to low or carbon-free energy sources can help significantly reduce greenhouse gas emissions from shipping, eventually reaching zero emissions. Figure 9 depicts the potential for reducing greenhouse gas (GHG) emission through the use of technology that contributes to the decarbonization of the shipping industry (Vidović et al., 2023).

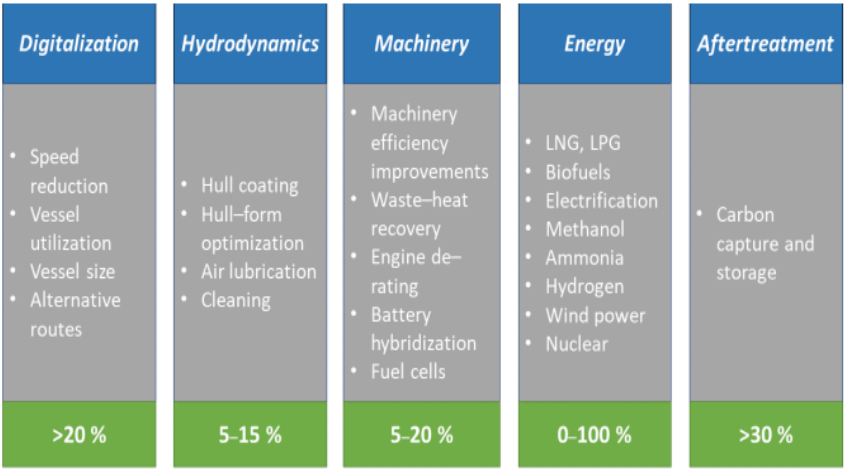

Figure 9: *Technologies that Have Potential to Reduce Greenhouse Emission (Vidović et al., 2023)*

The maritime industry is implementing various technical and operational solutions to improve energy efficiency and reduce greenhouse gas emissions. These include waste heat recovery systems, hull design improvements, energy-efficient engines, reducing vessel speed, and scheduling and routing optimization. Liquid natural gas (LNG) is being used in dual-fuel or gas engines, but its GHG savings are limited. Biofuels like biodiesel, bio-LNG, hydrogenated vegetable oil, synthetic diesel, and bio-methanol are being explored. Post-combustion carbon capture may be a temporary solution until zero-emission technologies are fully developed. Modern propulsion technologies like brid and all-electric systems are being explored. Hydrogen-powered proton exchange membrane fuel cells (PEMFC) are being developed for higher efficiency and cost-effectiveness. Wind or solar energy can also be used as an auxiliary energy in hybrid ship systems. Despite these advancements, there is no clear answer for the maritime sector to

efficiently cut greenhouse gas emissions, carbon emissions reduction strategies in the shipping industry still undergoing and Figure 10 represents their potential fuel savings.

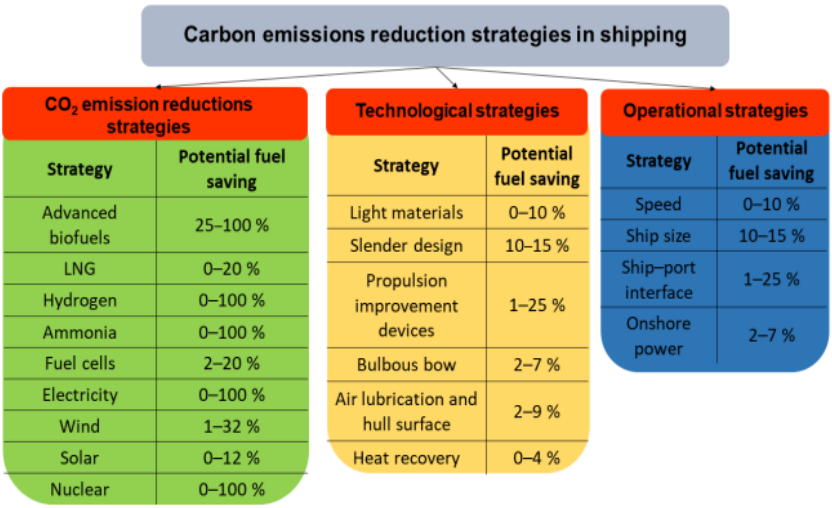

Figure10: *Carbon Emissions Reduction Strategies in Shipping Industry (Vidović et al., 2023).*

The highest possible emission reductions by 2050 are expected to fall between 75% and 85% due to reciprocal exclusivity and interdependence of initiatives. However, economic viability and technological readiness are two main obstacles to achieving these reductions. It is realistic to achieve only 50-60% reduction, leaving 40-50% of abatement responsibility to be addressed by zero-carbon fuels, carbon capture and utilization (CCUS), and out-of-industry transfers (Deng & Mi, 2023). The use of zero-carbon alternative fuels will become more practical in the long run. Short-term priorities include increasing shore power use, accelerating electric vessel pilot testing, and standardizing vessel types. The medium-term focus will be on encouraging new energy-efficient boats,

improving efficiency, decommissioning older vessels, and standardizing vessel types.

The strategies identified for reducing CO_2 emissions include concept, velocity, capability, hull and superstructure, power and propulsion systems, low-carbon fuel, renewable energy, fleet management, logistics, incentives, voyage optimization, and energy management.

6.2.1.Concept, Speed and Capability

Ship designs significantly impact energy efficiency, with factors like speed, size, and fundamental dimensions influencing efficiency. To meet the 25-30 year lifespan, careful consideration of energy efficiency and emissions is necessary. Larger ships have higher energy efficiency per unit of cargo, and doubling cargo capacity increases necessary power by two-thirds of the increase in ship size, resulting in less fuel use per unit of freight.

The relationship between velocity and emissions is crucial, as ships are designed to operate at specific speeds. Decreased speed can reduce fuel usage per unit of freight work. This can be achieved by using a smaller engine, reducing operational speed, or a combination of these methods.

Current research and design processes prioritize small improvements over critically questioning established practices. In the past, inexpensive fuel led to angular ships with significant resistance, while the Panama Canal's maximum permissible dimensions emphasized the dominance of rectangular designs.

There is a lack of research on the relationship between vessel slimness and fuel price, except for newer designs featuring larger

beams and drafts. Container vessels, originally designed for speeds of 25 knots or more, have decreased to 21-23 knots due to rising fuel costs and decreasing freight prices. However, there is a lack of research focusing on reducing emissions from maritime transport (Lindstad, 2013).

6.2.2.Hull and Superstructure

Ships face resistance during voyages, including friction and air resistance. Energy is used to overcome these resistances, reducing fuel consumption and CO_2 emissions. The hydrodynamics of the hull significantly impact this resistance. Constructing slender vessels can decrease hydrodynamic resistance but requires significant investments in maritime infrastructure. Regular hull maintenance and improving hull shapes can minimize resistance. Regular underwater and dry-dock cleaning can decrease fuel use by 9% and 17%, respectively. The HullMASTER program helps assess and compare maintenance techniques based on operational costs, health considerations, and environmental impacts (Vidović et al., 2023).

Marine vessels are typically designed to run at standardized maximum economic speeds under still water conditions. However, calm seas are rare in shipping, and these speeds are not based on economic calculations. The drag coefficient in still water increases quickly once a vessel crosses its critical speed threshold, with different hull forms having different resistance and power requirements. The most economic speed for a given design has historically been in the upper portion of the quarter circle, but the pace may now veer towards the lower end due to growing fuel costs and stricter environmental laws. The STAWAVE technique was

developed to measure additional resistance caused by waves, showing that vessels with an extended bow section face less resistance from waves (Lindstad, 2013).

6.2.3.Power and Propulsion

The design and optimization of ship power plants have traditionally focused on calculating the necessary number of engines or generator sets based on the total power needed to run under specific load and speed conditions. The most efficient strategy is to install engines with a capacity that allows the power output to reach the design speed within the range of 75% to 90% of the maximum possible power. However, due to recent surges in fuel costs and declines in freight rates, maintaining a consistent high-power output is no longer the most cost-effective option for all sea and loading conditions. New power solutions must operate efficiently at reduced engine loads, particularly when the ship is moving slowly in calm or following waves (Lindstad, 2013).

6.2.4.Low Carbon Fuels and Carbon Capturing Technologies

Carbon capture and storage (CCS) technologies aim to reduce CO_2 emissions, but large-scale solvent regeneration requires significant thermal energy. Substitute CCS technologies include liquefaction, membranes, direct air capture, algae-based capture, and calcium loops. Cryogenic carbon capture (CCC) is a promising technology due to its phase transition method. CCC can be advantageous in shipping applications, where efficiency improvements and sustainable bio-based fuels can reduce emissions by 50%. Onboard CCS systems can treat exhaust gases from ships' engines (Vidović et al., 2023).

Biofuels like biodiesel have potential to reduce shipping's environmental impact due to global warming, but they may have higher eutrophication potential and primary energy consumption. Liquefied natural gas (LNG) has a higher hydrogen to carbon ratio, resulting in lower CO_2 emissions compared to traditional hydrocarbon fuels. However, it can cause methane leakage in conventional low-pressure gas engines or dual fuel engines, reducing emissions from 25% to 15%. Using LNG in high-pressure engines decreases methane escape but may increase nitrogen oxide emissions, potentially causing non-compliance with emission standards for ships in the Baltic region. Hydrogen is an interesting fuel choice due to its low environmental impact and potential to generate energy using fuel cell technology. However, hydrogen synthesis requires significant energy, and it is crucial to evaluate novel hydrogen production techniques, particularly those using sustainable resources like wind energy (Lindstad, 2013).

6.2.5.Renewable Energy Sources

The overuse of fossil fuels and industry decline have hindered the development of renewable energy alternatives in marine transportation. Renewable energy sources include wind, solar photovoltaics, biofuels, wave energy, batteries, and supercapacitors. Integrating renewable energy into maritime transportation can be achieved through retrofitting current fleets or designing new vessels. Most renewable energy sources serve auxiliary functions, but few aim for 100% renewable energy or zero emissions in primary propulsion. Solar and wave energy sources have potential for producing environmentally friendly fuels (Mallouppas & Yfantis, 2021).

6.2.6.Exhaust Gas CO_2 Reduction

Steam turbines convert 40% to 50% of fuel energy into power when introduced into a ship's main engine, with the remaining energy lost as exhaust gas and heat exchange processes. Steam turbines recover some of this wasted energy, which can be used to power auxiliary equipment or improve the main motor's performance, potentially reducing CO_2 emissions by up to 12% on main fuel use. Empirical testing has shown up to 14% reductions in emissions (IMO, 2023).

6.2.7.Fleet Management, Logistics and Incentives

Speed reduction is a strategy used by ships to save fuel by running at slower speeds than their design velocity. This is because fuel consumption per unit of freight work decreases as vessel speed decreases, and speed optimization results in substantial fuel savings. However, port berthing regulations often prioritize first-come, first-served vessel entry, necessitating coordination with port planning. Speed reduction also affects fleet size in coastal or deep-sea commerce (Lindstad, 2013).

6.2.8.Voyage Optimization

Trip optimization systems determine the shortest path between ports of departure and arrival, reducing resistance and fuel consumption within specific freight markets. They use weather, current, wave data, and vessel parameters to calculate extra resistance and fuel usage. Models that calculate extra resistance and fuel usage based on vessel speed and sea conditions, combined with weather and wave forecasts, can result in significant cost and emission savings. However, recent advancements in hull and propulsion technology, algorithmic breakthroughs, computing

capacity, and weather forecasting methods have not been extensively studied (IMO, 2023).

6.2.9.Energy Management

Energy management is a process aimed at reducing emissions in various aspects of ship operations, including auxiliary machinery, hotel loads, engine maintenance, and hull and propeller maintenance. Shipowners like Det Norske Veritas use it to minimize fuel consumption and validate these reductions through onboard measurements. Innovative technologies like LED lighting are also used to reduce baseline usage. The effectiveness of energy management measures depends on the vessel's operational efficiency and auxiliary power usage to total energy consumption.

The Ship Energy Efficiency Management Plan (SEEMP) is a strategic plan for new and existing vessels to improve fuel economy through operational changes. It includes enhancements like increasing maintenance frequency, optimizing vessel velocity, and selecting alternative routes to avoid adverse weather conditions. The plan is tailored to each vessel's specific requirements, including route characteristics, cargo type, dry docking dates, and overall fleet or corporate goals. The Energy Efficiency Design Index (EEDI), introduced in 2001, is a benchmarking tool for ship owners and operators to assess the impact of operational adjustments. EEDI promotes decreases in CO_2 emissions, establishing the first worldwide requirement for CO_2 emission limits. The International Council on Clean Transportation (ICCT) projects that not all vessels will comply with EEDI rules by 2040-2050. The International Maritime Organization (IMO) recommends the Energy Efficiency Operational Indicator (EEOI) to assess the efficiency of maritime

shipping procedures. EEOI measures CO_2 emissions per unit of transportation work, considering fuel consumption and emissions from boilers, incinerators, and engines. Japan has pushed for the adoption of interim measures like the Carbon Intensity Index (CII) and the Energy Efficiency Existing Ship Index (EEXI), which is modified for current ships (IMO, 2023).

The Energy Efficiency Existing Ship Index (EEXI) is a new metric introduced by the International Maritime Organization (IMO) in November 2020. It is a development of the Energy Efficiency Design Index (EEDI) and aligns with requirements for newly built ships. The EEXI measures carbon dioxide emissions per unit of cargo ton and distance, clarifying emissions related to engine capacity, cargo-carrying capability, and vessel speed. It sets limits on CO_2 emissions per unit of transported goods. However, the EEXI is a technical or design metric, lacking past data and requiring onboard evaluations (Mallouppas and Yfantis 2021).

7.Methodology

The research topic for this study is to analyze the sustainability concept, global implications of marine fuels, the brief history of maritime, and alternative fuels, and measures for reducing emissions. A qualitative methodology has been employed to ascertain the response to the research inquiry and arrive at a definitive conclusion. Initially, a comprehensive literature research was conducted, encompassing books, theses, articles, and webpages relevant to the subject matter of this thesis. These sources were thoroughly reviewed and examined. Subsequently, the sustainability concept has been defined to provide a clear understanding of the study's focus. Furthermore, an analysis was conducted on the

worldwide influence of marine fuels. Furthermore, a concise overview of maritime history was examined. Ultimately, an analysis was conducted on alternate fuels and measures to reduce emissions.

8.Conclusion

Sustainability is a concept aimed at balancing environmental impact, economic stability, and social equity to meet present needs without compromising future generations' ability to meet their own needs. The maritime industry, for instance, balances these aspects to ensure long-term sustainability. The Brundtland Report by the United Nations outlines sustainability criteria. The maritime sector's sustainability involves economic, social, and environmental aspects. Economic sustainability focuses on operational efficiency and profitability, while social sustainability promotes safety, improved working conditions, and community engagement. Environmental sustainability aims to minimize pollution, reduce carbon emissions, protect marine ecosystems, and promote responsible resource management. Industry 4.0 technologies are increasingly integrated in the maritime industry to enhance efficiency, reduce environmental impact, and improve safety standards.

The maritime sector is increasingly adopting alternative fuels and emission reduction strategies to promote environmental sustainability. Wind-Assisted Ship Propulsion (WASP) technology is a promising solution for decarbonization, aiming to replace fossil fuel-generated propulsion with wind power. WASP has the potential to achieve fuel savings ranging from 2.6% to 22%. Despite its limited adoption compared to the global commercial maritime fleet, there is a noticeable upward trend in the proliferation of WASP technology. This indicates that while the current adoption may be

modest compared to the total number of vessels, its acceptance is gradually gaining traction.

Furthermore, the marine environment's sustainability is impacted by factors like air pollution, ballast water pollution, overexploitation, and climate change. Air pollution releases toxic substances, while ballast water pollution disrupts ecosystems and introduces invasive species. Overfishing leads to ecosystem disturbances, decline in marine biodiversity, and economic losses. Climate change, caused by melting glaciers and ice caps, increases sea temperatures and ocean acidity. Organizations like MARPOL, UNCLOS, and BWM are established to ensure environmental sustainability and mitigate pollution.

The study explores alternative fuels for reducing emissions from maritime traffic, focusing on liquefied natural gas (LNG) as a primary alternative due to the rapid growth of bunker infrastructure. LNG offers significant advantages in local pollution emissions compared to traditional marine petroleum fuels, and the transition from these fuels is expected to significantly decrease major air pollutants like SOx, NOx, and PM10. However, the effectiveness of LNG in reducing greenhouse gas emissions from ship operations is limited, with the true ability of LNG to reduce emissions falling within the 8-20% range when comparing HFO and MGO. To achieve a 50% decrease in emissions, the study recommends not only switching to LNG but also implementing other measures like slow steaming or introducing blends of liquefied biogas (LBG).

Hydrogen and ammonia are potential alternatives to traditional fuels in maritime operations due to their high energy density and low emissions. However, barriers like high capital

investment costs and fuel supply uncertainties hinder their widespread adoption. Hydrogen is one of the most expensive fuel-propulsion combinations, and infrastructure and distribution networks are crucial for its widespread use. Existing LNG infrastructures have potential for hydrogen distribution, but further scrutiny is needed to confirm feasibility. Ammonia, with its high hydrogen gravimetric density and ease of storage and distribution, has gained attention due to its high density and ease of storage. However, achieving ammonia-fueled ships requires overcoming technical hurdles and safety concerns.

Renewable electricity is becoming a significant part of the global energy mix, offering environmental and economic benefits for ship propulsion. Battery-electric vessels use renewable electricity, resulting in minimal climate impact and minimal exhaust emissions. However, technical challenges like poor energy density and short lifespans need to be addressed for widespread commercial use of battery-powered ships.

The use of alternative fuels in the maritime sector has shown variability in reducing greenhouse gas emissions, depending on the raw materials used. Transitioning from carbon-intensive production pathways to lower carbon content may not always result in reductions in emissions, but may lead to emissions being relocated from vessel operations to fuel production facilities. Decarbonization of fuels like hydrogen, electricity, and ammonia depends on low-carbon energy inputs and feedstocks. Addressing challenges extends beyond the maritime sector, as alternative fuels play a crucial role in global maritime transport.

Even if most people believe that marine vessels are among the greenest forms of transportation, they nevertheless produce a substantial amount of greenhouse gas emissions. Especially in coastal areas, emissions from international maritime vessels have a significant effect on public health and air quality. Additionally, it is expected that emissions from the maritime industry would increase significantly as the world economy and trade do. Even with improvements in the reduction of emissions from land-based sources, NOx, SOx, and PM emissions from ships are predicted to increase at a pace that is proportionately greater.

Strategies such as concept, speed, capability, hull and superstructure, power and propulsion, renewable energy sources, low carbon fuels, fleet management, logistics, voyage optimization, energy management, and industry perspectives are essential for reducing emissions in transportation. By streamlining procedures, designing effective routes, and using lightweight and aerodynamic materials in hull and superstructure design, ship resistance can be reduced, and fuel consumption and emissions can be reduced. Fuel-efficient engines and propulsion systems can also help vessels use less fuel, further reducing emissions.

Moreover, Low Carbon Fuels and Carbon Capture Technologies have the potential to mitigate greenhouse gas emissions in the maritime industry. Incorporating renewable energy sources into ship power generating can help reduce emissions. The technologies that were discussed include wind power, solar power, and biomass energy. Nevertheless, these technologies are still lacking sufficient independent development to effectively

accomplish significant decarbonization, indicating a requirement for additional advancement.

Conclusively, it is indicated that the deployment of exhaust gas scrubbing systems and technologies aimed at exhaust gas reduction can effectively lower carbon emissions from ships. Fleet management optimization, coupled with the implementation of incentives, can incentivize ship operators to adopt greener and lower-emission operational practices. Additionally, optimal route planning and voyage optimization strategies can curtail fuel consumption, consequently diminishing emissions. Furthermore, the adoption of more efficient energy management techniques and the incorporation of industry perspectives can contribute to the transformation of ship operations toward greater environmental sustainability.

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CHAPTER III

Traits of Critical Thinking

Oya ÖNALAN[1]

INTRODUCTION

Critical thinking refers to the ability to use clear reasoning and critical thinking to evaluate debates, identify biases, and make logical decisions. It involves using expert judgment and expert observation to evaluate facts, develop compelling arguments, and make rational choices, ensuring a balanced and critical approach to decision-making.

Dewey (1910) coined the phrase "critical thinking" to describe an educational objective that he associated with a scientific mindset. He more frequently referred to the objective as "reflective

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thought," "reflective thinking," "reflection," or simply "thought" or "thinking."

Petress (1984) defines critical thinking as a set of characteristics essential in decision-making processes. It involves evaluating information based on sufficiency, relevance, reliability, consistency, recency, access, and objectivity. These conditions ensure adequate support claims, relevance, reliability, consistency, and access to relevant information. He emphasizes the importance of ensuring fair, undistorted, and expert sources in supporting materials for effective analysis and evaluation.

Lipman (1988) defines critical thinking as skilled, responsible thinking that supports sound judgment by self-correcting, relying on criteria, and being sensitive to context. According to Paul and Binker (1990) disciplined thought guided by well-defined intellectual criteria is what critical thinking is. Clarity, accuracy, precision, relevance, consistency, logical correctness, completeness, and justice are some of the most crucial of these intellectual criteria.

Facione (1990) specifies critical thinking as intentional, autonomous judgment that includes assessment, interpretation, scrutiny, and inference in order to explain the philosophical, scientific, proof-based, or criteriological components that underlie a judgment,

Using a collection of reflecting attitudes and skills that inform thoughtful ideas and behaviours, critical thinking is a conscious and intentional process that is used to understand or analyse knowledge and past experiences (Mertes, 1991). The study

highlights that a wide range of factors may either promote or restrict critical thinking. In order to improve theoretical knowledge of the factors that determine critical thinking, this study examines the elements that influence critical thinking, particularly in workplace settings, and focuses on scholarly articles. The goal of this literature study is to look at how critical thinking and decision-making have advanced.

LITERATURE REVIEW

Since critical thinking influences our thoughts, behaviours, and choices, it is relevant to both workplace management and personal growth. Our automatic thought processes are controlled by critical thinking, which also provides us with the ability to learn, investigate, and protect ourselves from prejudices, fallacies, influences, and mistakes. The ability to think critically necessitates not accepting what we see or hear and making an effort to classify reality as generally held and impartial.

Chartrand, Ishikawa, and Flander (2013) emphasize the importance of critical thinking **i**n decision-making. It helps distinguish between belief and reality, identifying presumptions based on bias or emotions. This process promotes objectivity and composure, preventing bias and promoting objectivity. It emphasizes the importance of combining and contrasting information to reach logical conclusions.

Tripathy (2019) states that critical thinking aids in generating innovative ideas for problem-solving, task completion, writing, and influencing change, particularly among curious, questioning, research-oriented individuals who are passionate about transforming

ideas into action. Rickards (1997) categorizes problems into open-ended and closed-ended types, emphasizing the importance of critical thinking in solving these problems. Closed-ended problems are resolved through rational conclusions, while open-ended problems lack clear definitions or disagreements due to differing perspectives. Despite the diverse nature of problems, critical thinking is crucial for tackling them beyond the logical approach.

What is Critical Thinking

According to Mayer and Goodchild (1990) critical thinking is a methodical approach to comprehending and assessing ideas. An argument offers proof to either confirm or deny a claim on the characteristics of an object or an interaction between two or more objects. Critical thinkers recognize that there is no one right way to interpret and assess arguments, and that not every effort will be successful.

Critical thinking is the process of designing, applying, interpreting, combining, and assessing data obtained by observation, expertise, introspection, deductive thinking, or communication is known as critical thinking (Scriven and Paul, 1992).

According to Petress (1984) critical thinking is a collection of qualities that must be present during the decision-making process. If the following circumstances are met, information and how it is used can be critically assessed: *Sufficiency:* The thinker assigns a score to the evidence by considering how well the arguments and premises are supported by the evidence. *Relevance:* According to the thinker, the evidence is relevant to the current problems. *Reliability:* The arguments for support have a solid history. *Consistency:* The

supporting components are both internally and externally consistent with one another and with the knowledge we have gained from other sources, experiences, and observations. Stated differently, we possess sufficient data to conduct a thorough examination and assessment of the matter at hand. *Recency:* Rather than being outdated, the accompanying materials are up to date. *Access:* The supporting documentation is available for recipients to review. *Objectivity*: The supporting information is impartial, unaltered, and comes from reliable sources. Information sources are fully disclosed, made public, and subject to examination.

Facione (2015), describes critical thinking as a human phenomenon characterized by strong problem-solving abilities, cognitive capacities, and a holistic perspective on life. It involves focusing on the issue, persevering despite challenges, handling complexity, obtaining relevant information, choosing criteria, articulating concerns, persisting despite obstacles, and ensuring precision.

Saadeh (2011) defines critical thinking as a set of elements involving problem-solving, data analysis, proof strength assessment, self-aspirations, assumptions, ambiguous information, induction and deduction techniques, and logical errors. It involves prior knowledge, engagement with stimuli, critical thinking abilities, and conclusion-driven judgments and decisions.

Fisher (2001) outlines the key elements of critical thinking in academics, including providing a well-supported case, assessing underlying assumptions, elucidating concepts, assessing arguments' veracity, providing explanations, and making deductions.

Novella (2012) provides a guideline for applying critical thinking to an issue, which includes examining beliefs, checking reasoning for biases, considering implications, consulting others, recognizing one's knowledge limitations, and accepting uncertainties and limitations in one's understanding.

Butterfield (2017) highlights two approaches on critical thinking: intuitively and systematically. Intuitive problem-solving involves immediate, natural responses, while systematic problem-solving applies previous solutions to current circumstances. The latter involves a methodical, structured procedure, generating ideas, analysing options, and weighing advantages and disadvantages. Choosing the best option can be challenging due to the abundance of options, so it's essential to monitor remedies to ensure the issue is resolved.

Al-Sayed (1995) outlines the critical thinking process as a multifaceted process consisting of five interconnected elements: knowledge base, exterior events, personal theory, feeling of divergence or contradiction, and resolving the conflict. The knowledge base refers to an individual's beliefs and knowledge, while exterior events trigger contradicting feelings. Personal theory refers to an individual's cognitive attributes. The process involves a series of stages and components to resolve the conflict.

Natale and Ricci (2006) highlight the importance of group gatherings in fostering critical thinking abilities. They argue that these abilities, when applied in a collaborative setting, can lead to successful organizational changes, requiring team judgment, analysis, interpretation, and conclusions.

Critical thinking involves self-directed, self-disciplined, self-monitored, and self-corrective thinking, requiring mastery of application, problem-solving, effective communication, and overcoming sociocentrism and egocentrism. *A critical thinker* must openly evaluate alternative systems of thought, formulate important questions, gather relevant information, and communicate effectively to arrive at well-reasoned solutions, utilizing abstract ideas for effective interpretation and problem-solving (Paul and Elder, 2008).

According to Paul and Elder (2013) leadership involves making crucial decisions that directly impact individuals' quality of life. Critical thinking in decision-making encourages conscious, purposeful choices and increases the likelihood of logical and reason-based decisions, thereby enhancing the overall quality of life, they also emphasize the importance of combining decision-making with critical thinking for exceptional outcomes. Critical thinking allows decision-makers to analyse situations, compare theories, and reach logical conclusions. They argue that applying critical thinking raises the pattern of conscious and deliberate choice, enhancing the rationality of decisions and determining an organization's growth or failure.

Significance of Critical Thinking

Warnick and Inch (1994) stress on the importance of critical thinking in evaluating decision makers' arguments and hypotheses. They highlight the various aspects of critical thinking, including dynamic and rhetorical discussions, which lead to better judgments and organizational performance. They also highlight the need for critical thinking in formal and informal cultures, where it is often discouraged for a sense of belonging.

Moisescu and Golomoz (2018) emphasize the importance of critical thinking in the workplace, highlighting its significance in evaluating ideas without prejudice or discrimination, and how competition significantly influences organizational rivalry tactics, emphasizing the need for effective communication channels in job functions and management.

Paul and Elder (2013) focus on the importance of accurate and adequate knowledge in critical thinking as well. They argue that false knowledge, misconceptions, prejudices, and illusions hinder fair judgments and decisions. Therefore, it's crucial to carefully absorb concepts, data, and knowledge to progress to the next level.

Siegel (1990) describes the significance of critical thinking, which is unbiased, logical, and non-arbitrary, based on principles of impartiality, equity, and objectivity. It encourages growth in self-discipline, perseverance, humility, integrity, and empathy. Critical thinking involves evaluating and improving reasoning, analysing ideas, striving for honesty, fairness, courage, persistence, and intellectual modesty. It helps identify potential flaws in thinking, enabling productivity, discerningness, and fulfilling moral and social obligations.

Characteristics of a Critical Thinker

Ferrett (1997) defines a critical thinker as an individual who actively investigates facts, viewpoints, and views, posing relevant inquiries and focusing on the main topic. They review arguments, premises, and hypotheses for value, objectivity, and focus, assessing claims for coherence and veracity. Critical thinkers are inquisitive individuals seeking novel solutions and expanding their knowledge.

They are subject-matter experts in their field, articulating standards for evaluating concepts, analysing and comparing thoughts with facts, providing insightful comments, and attentive listening. They are lifelong learners, actively engaging in self-evaluation and continuous learning to contribute to the world.

Critical thinkers are nimble, adaptable, and able to understand new ideas, anticipate challenges, and quickly capitalize on fresh information, giving businesses a competitive advantage in an ever-evolving market.To cultivate intellectual qualities, critical thinkers regularly use the intellectual standards to the components of reasoning.

Critical Thinking Skills

Figure 1: *Core Critical Thinking Skills*

Resource: Adapted from Facione (2015) *Critical Thinking: What It Is and Why It Counts.* Insight assessment

Interpretation involves categorizing, significance decoding, and meaning clarification as subskills, ensuring understanding and communication of diverse experiences, circumstances, facts, events, judgments, customs, beliefs, rules, procedures, or criteria.

Analysis involves determining inferential relationships among statements, questions, concepts, descriptions, or other representations to express beliefs, judgments, experiences, reasons, information, or opinions, with subskills including idea examination, argument detection, and analysis.

*Evaluation i*nvolves assessing the logic and strength of inferential connections within claims, descriptions, and questions, while subskills include assertion credibility and evaluating arguments using deductive or inductive reasoning.

Inference involves identifying and securing elements for hypotheses, conjectures, and deductions from statements, data, and opinions, with subskills including questioning facts, speculating, and forming conclusions.

Explanation involves providing a clear and concise explanation of one's reasoning, encompassing abstract, methodological, criteriological, and contextual variables. It involves providing thorough, well-reasoned arguments, describing approaches, defending procedures, and presenting causal and theoretical explanations of events or points of view.

Self-regulation involves self-monitoring cognitive activities, using analysis and evaluation skills to evaluate inferential judgments, and correcting reasoning or results, with subskills including self-correction and self-examination

Universal Intellectual Standards of Reasoning

Elder and Paul's (2010) goal is for the intellectual standards of reasoning to become ingrained in all thinking, guiding better and better reasoning, and good critical thinking requires command of these standards.

Clarity is essential for ensuring understanding, removing ambiguity, and removing obscurities, as it is crucial for determining the accuracy and relevance of a statement.

Accuracy guarantees that a statement accurately depicts what it really is; it is the truth, devoid of faults, blunders, or distortions.

Precision refers to being exact to the necessary level of detail, while thinking is always more or less precise, and understanding a statement depends on specificity.

Relevance refers to a logical relationship with the matter under consideration, ensuring clarity, accuracy, and precision. Thought can stray from the task, question, problem, or issue, and individuals should assess their thinking only when considering relevant issues.

Depth in thinking involves thoroughness in considering complexities and multiple interrelationships in a situation, context,

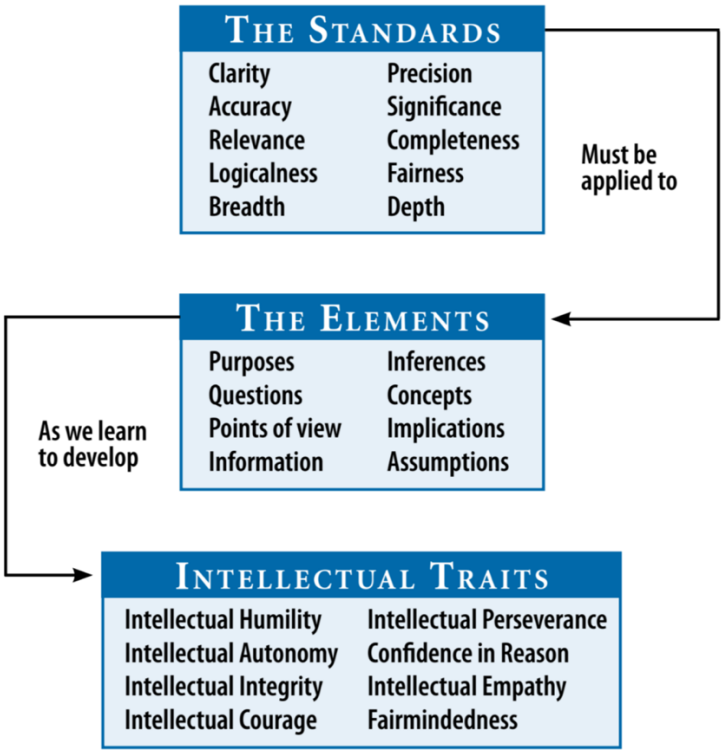
idea, or question. A statement's clarity and relevance can be superficial, but a line of thinking is fully assessed.

Breadth of thinking involves considering multiple viewpoints and perspectives, allowing for insightful reasoning within multiple frames of reference. It requires an individual to determine the required breadth of thinking to fully understand a line of reasoning**.**

Logic is the belief that everything makes sense when taken as a whole, consistent with reasonableness and good judgment. It involves organizing ideas into a coherent whole, while non-logical ideas lack common sense or support.

Significance describes something's importance, impact, or major meaning. Not all ideas are equally significant, thus it's critical to concentrate on the most pertinent facts and concepts when examining a problem. Furthermore, a thinker should concentrate on the most substantial, significant, and relevant implications rather than on trivial issues.

Fairness guarantees that all points of view be given equal weight without prejudice or partiality. Since everyone has a tendency to favor their own point of view, it is imperative to uphold an intellectual requirements for fairness in thinking. This is particularly crucial in circumstances that call for us to consider challenging elements or give up items we would rather not. The thinker must focus on the issue at hand while evaluating many points of view in a sincere manner.



Paul, R. and Elder, L. (2010). The Miniature Guide to Critical Thinking Concepts and Tools. Dillon Beach: Foundation for Critical Thinking Press.p.21

Critical Thinking Process

Kallet (2014 presents a framework for critical thinking, emphasizing *clarity, conclusions, and decisions*. He suggests that utilizing and practicing these methods can enhance problem-solving and decision-making skills. Critical thinking involves understanding a situation, making decisions, and acting on them. Benefits include improved problem-solving, better judgment, and quicker results.

Clarity is a crucial element in critical thinking, enabling us to identify the true nature of problems, issues, or objectives, which is often overlooked in headscratchers, leading to failures. *Conclusions:* Once you have a clear understanding of the problem you need to solve, you need to decide how to proceed. Conclusions include answers to your problem and an inventory of things you need to accomplish. *Deciding*: After deciding what steps to take, you must genuinely decide to take them and follow through on them.

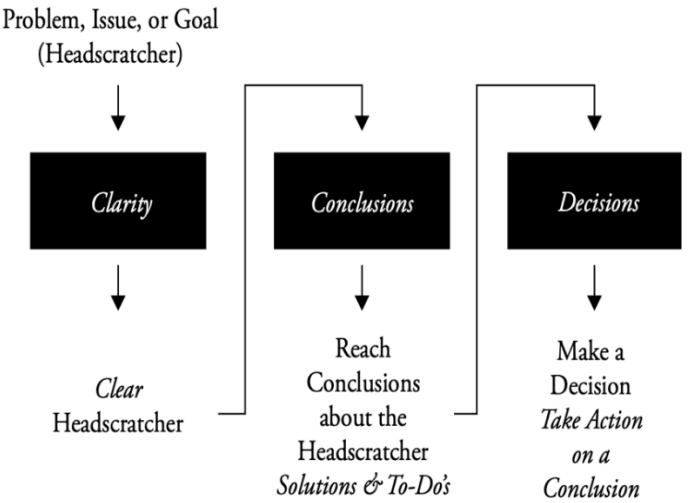


Figure 3. The Three-Step Critical Thinking Process

Resource: Adapted from Kallet, M. (2014). Think smarter: Critical thinking to improve problem-solving and decision-making skills. John Wiley & Sons. p. 20

Barriers to Critical Thinking

Pinder (2007) highlights eight obstacles to effective critical thinking in organizations and the work environment. These include

C*onfirmation bias*, where data is manipulated to support beliefs, ***A****ttribution bias*, where positive experiences are attributed to actions, and ***T****rusting testimonials*, which often contain inaccurate information, which can hinder critical thinking and hinder the process of evaluating evidence, and *Memory lapses* can lead to biased judgments, as people often fill in gaps with incorrect or accurate facts, and ***A****ccepting authority without question* refers to individuals willingly executing powerful shocks on authority orders, despite uncertainty about the rightness of the action, and in consumer marketing and board discussions, and it's crucial to resist ***Ge****neralizing from insufficient observations* by seeking unbiased opinions from lower-level employees. ***I****gnorance* often leads to fabricated information and wild speculation, as individuals may fake their lack of knowledge to appear foolish, so be cautious of those who quickly answer questions, and ***C****oincidence*, or the Law of Truly Large Numbers, is the mistaken belief that information has causality when it is a result of a pure coincidence or the law of large numbers.

CONCLUSIONS

Establishing an atmosphere that promotes cooperation, candid communication, and tolerance for different viewpoints, ideas, and beliefs is crucial. People should be free to voice their thoughts without worrying about criticism, condemnation, or retaliation. Supervisors can promote the best critical thinking attitudes and behaviours by effectively modelling them.

Critical thinking techniques at work enhance output, promote creativity, and foster a cooperative atmosphere. They enable problem-solving, offer constructive criticism, and reach informed conclusions. Encouraging critical thinking encourages questioning,

creativity, and business growth. Problems can occur at any time in the workplace, and managers need to be able to recognize, evaluate, and resolve them fast and effectively. Critical thinking abilities can assist leaders in determining the underlying source of an issue and weighing potential solutions. This procedure might result in creative and practical answers to challenging issues that could have been disregarded or ignored otherwise. It is anticipated that this brief overview of the function of critical thinking abilities would help clarify some confusing difficulties surrounding this subject.

Critical thinking enhances cooperative reasoning, creative tasks, and enhances arguments, theories, and knowledge, improving social systems and work practices. The aforementioned methods aid team members in making informed decisions on challenging projects by promoting critical thinking. It encourages in-depth discussion and can be applied in various fields like project management, strategic planning, and dispute resolution. It encourages wise decision-making and quantifiable action steps.

Critical thinking can improve communication by fostering clarity, correctness, and appropriateness in the interchange of ideas; it can stimulate creativity by requiring the investigation of various points of view and solutions; and it can create social harmony by fostering candid and open dialogue.

Good critical thinking is all about transforming ideas into habitual behaviour. Like any other behaviour in life, critical thinking is something that can be improved and is worthwhile. Managers should be aware that their critical thinking abilities may be lacking

and work to develop them. However, they won't know which skills to work on if they don't know what they are.

Elder and Paul (2007) argue that traditional education is not adequately fostering intellectual capacities for academic and personal success. Students are often asked to simply take down facts, limiting their ability to make deductions and engage in sophisticated discussions. As the world's financial system becomes more complex and interconnected, traditional training in limited fields is no longer effective for achieving career success.

I would like to conclude that the ability to think critically is crucial for both academic and professional success. Giving youngsters the chance to hone their critical thinking abilities will make them successful pupils, innovative thinkers, and citizens in a world that is changing constantly.

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CHAPTER IV

Artificial Intelligence and Its Effects on Work Life

Adeviye ERDOĞAN[1]

Introduction

Artificial Intelligence (AI) has become one of the most striking areas of technological development in recent years. With its subfields such as machine learning, deep learning, and natural language processing, artificial intelligence offers the potential to imitate human characteristics like decision-making, problem-solving, and creativity. "Artificial Intelligence is the science and engineering of making intelligent machines" (McCarthy, 2007). "Artificial Intelligence is the science of making machines that can

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perform tasks requiring intelligence carried out by humans" (Minsky, 1968).

Artificial Intelligence is a successful discipline. Its range of applications has significantly expanded over the years. There are successful applications in fields such as computer vision, speech recognition, music analysis, machine translation, text summarization, information retrieval, robotic navigation and interaction, automated vehicles, gaming, forecasting, estimation, planning, automated inference, expert systems, and so on (Russell & Norvig, 2009).

This specialization has led to an application-specific (task-oriented) assessment. In fact, moving from an abstract problem to a specific task is encouraged (Cohen & Howe, 1988). Clearly, performance, not intelligence, is being measured. In reality, most of the most successful AI systems solve problems differently from the way humans solve the same problems. Additionally, AI systems often include large amounts of embedded programming and knowledge for the task. It is not the system but the researchers who designed the system that are evaluated. The world is witnessing the beginning of a new industrial revolution, expected to have a profound impact on global industries (Aazam, Zeadally & Harras, 2018; Acemoglu & Restrepo, 2020). This is a new era of combining the physical world with the digital world (Pereira et al., 2023), enhancing human-machine interactions, and promoting automation through the integration of intelligent machines and intelligent software (Ibarra, Ganzarain & Igartua, 2018).

Rooted in philosophy, mathematics, computation, psychology, and neuroscience (Kumar & Thakur, 2012), AI is becoming increasingly useful in both production and service sectors (Ibarra et al., 2018; Müller, Buliga & Voigt, 2021). AI aims not only to enable machines to think like humans but also to surpass human ways of working (Misselhorn, 2018). It equips machines with the autonomous ability to collect and process information from their environments to make decisions, solve problems, and undertake other actions requiring human reasoning (Von Krogh, 2018). AI is increasingly being incorporated into business to improve task execution and performance (Lee et al., 2018) and is associated with computer-based systems and applications such as machine learning (Chui, Manyika & Miremadi, 2015), soft computing (Kumar & Thakur, 2012), fuzzy logic systems (Karatop, Kubat & Uygun, 2015), intelligent robots (Liu, Shi & Liu, 2017), and virtual and augmented reality (Abou-Zahra, Brewer & Cooper, 2018).

The human resources management function of an organization plays a significant role in effectively integrating AI into the workplace (Lawler & Elliot, 1993; Strohmeier & Piazza, 2015). Integrating human resources management processes with AI can provide additional benefits for an organization (Minbaeva, 2020), such as improved managerial decisions (Liboni et al., 2019), faster and more effective employee recruitment processes (Reilly, 2018), better workplace learning (Hamilton & Sodeman, 2020), employee engagement (Tripathi, Ranjan & Pandeya, 2012), and employee retention (Samarasinghe & Medis, 2020).

In conclusion, AI evaluation focuses on checking whether machines perform these tasks well. The impact of this technology

has not been limited to scientific research or the technology sector alone; it has transformed all aspects of business life, triggering a global revolution. This chapter examines the effects of AI on business life across different dimensions, from employees' roles to corporate structures and future predictions.

1. The Transformative Role of Artificial Intelligence in Business Life

AI continues to revolutionize the business world today. This technology is used across a wide range of areas, from production to service sectors, enabling companies to increase their efficiency, reduce costs, and gain a competitive advantage. In particular, AI applications, ranging from robots on production lines to digital assistants in offices, significantly improve business effectiveness (Brynjolfsson & McAfee, 2017). Automated production processes in factories represent one of the most obvious examples provided by AI, where production speeds increase while error rates are minimized (Davenport & Westerman, 2018).

In the logistics sector, AI applications allow for the rapid analysis of big data, particularly through route optimization algorithms. These algorithms significantly reduce delivery times for logistics companies while also lowering fuel consumption, thus contributing to environmental sustainability (Baryannis et al., 2019). A report published by McKinsey & Company in 2023 reveals that AI technologies have the potential to increase workforce productivity by 40%, thereby creating a major transformation in the business world (McKinsey, 2023). This finding demonstrates that AI

offers not only cost-reducing opportunities for companies but also significant advantages in terms of sustainability.

In the healthcare sector, the impact of AI is becoming increasingly evident. AI-based diagnostic tools accelerate doctors' decision-making processes while improving accuracy rates. For example, a study published in Nature Medicine revealed that AI algorithms can diagnose cancer with accuracy rates similar to those of human radiologists (Esteva et al., 2019). This finding highlights the potential of AI in healthcare and its role in enhancing service quality in this field. Additionally, AI-based tools enable faster and more accurate interventions during patients' treatment processes, increasing the efficiency of healthcare services.

The impact of AI is also being felt rapidly in the financial sector. AI-supported analytical tools based on big data analysis help financial institutions make more accurate and precise investment decisions. According to PwC's 2023 report, AI technologies improve risk management in financial institutions while achieving success rates of up to 80% in fraud detection (PwC, 2023). This underscores AI's importance not only as a tool for operational efficiency but also as a significant asset for security.

Customer service is another area where AI applications are widely used. AI-supported chatbots and natural language processing algorithms automate customer service processes, providing 24/7 support and increasing customer satisfaction. According to predictions made by Gartner for 2024, more than 70% of customer service processes will be managed by AI-based systems by 2025

(Gartner, 2024). This enables companies to reduce operational costs and elevate customer satisfaction to higher levels.

The transformation provided by AI in the business world is not limited to economic benefits. It also offers significant contributions to societal and environmental sustainability. AI's potential to optimize environmentally friendly production processes is of great importance, particularly in areas such as reducing carbon emissions and improving energy efficiency (Chien et al., 2020). For example, smart manufacturing and Industry 4.0 applications enable businesses to produce more with fewer resources.

The potential of AI technologies in the business world is being discovered by an increasing number of sectors each day. AI not only enhances workforce productivity but also makes significant contributions to critical areas such as environmental sustainability, security, and customer satisfaction. Therefore, the future role of AI is gaining importance not just as a technological innovation but also as a tool for societal and environmental transformation.

2. Artificial Intelligence in Human Resources and Talent Management

AI is driving revolutionary changes in Human Resources (HR) management. In particular, AI-based applications in core HR functions such as talent management, training, and employee performance monitoring enable employers to make more effective, data-driven, and strategic decisions. Talent management is a critical area where businesses gain a competitive advantage, and AI makes these processes more efficient and goal-oriented (Angrave et al.,

2016). Talent management strategies play a crucial role in helping organizations recruit, develop, and retain top talent. Examples of how AI is used to optimize these strategies show that organizations improve their workforce planning (Cappelli, 2019).

AI-based systems that analyze candidates' resumes not only save time and costs but also minimize biases in recruitment processes. Such systems have the capacity to identify the most suitable candidates by considering elements such as past experience, skill sets, and personality traits (Huang et al., 2020). According to IBM's 2023 Human Resources Report, AI-based recruitment systems increase accuracy in candidate selection by 85% (IBM, 2023). This increase in accuracy helps businesses build a more skilled and diverse workforce, thereby enhancing their innovation and productivity capacity.

Training and employee development are critical components of talent management, and AI has a significant impact in this area as well. Traditional training methods often fall short due to time and location constraints, while AI-supported training programs enhance employees' competencies, thereby strengthening their job satisfaction and commitment (Zhao & Chen, 2020). AI-assisted learning platforms make training processes more efficient and personalized by offering content tailored to employees' individual needs (HBR, 2023). These platforms enable employees to acquire skills more quickly while increasing the overall competency levels of organizations. According to Coursera's 2024 report, AI-based learning platforms accelerate skill acquisition processes by 60% by providing employees with personalized learning experiences

(Coursera, 2024). This development is particularly critical in sectors with dynamic workforce requirements.

AI also plays a significant role in performance evaluation processes. AI-based analytical tools monitor employee performance in real time, providing data-driven feedback to managers and enabling employees to achieve their goals more quickly (Deloitte, 2023). Beyond performance evaluation, these systems track employee development and promote continuous improvement. AI's ability to objectively identify employees' strengths and areas for development makes performance management processes fairer and more effective (Aguinis & Pierce, 2020). Additionally, it is emphasized that AI increases employee satisfaction and reduces turnover in these processes. This provides a significant advantage, especially for sectors struggling with high employee turnover and low employee engagement (Huselid, 2018).

The integration of AI into talent management processes not only increases organizational efficiency but also improves the employee experience and fosters a more inclusive culture in the workplace. Talent management is not limited to recruitment and performance management; it also encompasses employees' career development, training needs, and leadership potential (Collings & Mellahi, 2009). In this context, AI identifies each employee's potential more accurately and quickly, recommends appropriate training programs, and guides career development. This allows businesses not only to hire the most talented individuals but also to develop strategies for enhancing the growth of their existing employees (Guthridge et al., 2008).

AI applications in talent management not only enhance organizational efficiency but also help manage talent more effectively and strategically. This transformation allows businesses to build a more sustainable and innovative workforce. Effective use of AI in areas such as talent acquisition, development, and performance management contributes to organizations achieving their strategic goals and facilitates gaining a competitive advantage.

3. Artificial Intelligence and Occupational Safety

Artificial Intelligence (AI) is emerging as an effective tool in the field of occupational safety. Innovative solutions provided by AI play a significant role in preventing workplace accidents and enhancing worker safety. Sensors and AI-based analytical systems help prevent accidents by predicting potential hazards. For example, AI-supported image processing technologies in the construction sector monitor worker behaviors, identify safety violations, and thereby reduce accidents by 25% (Gao et al., 2021).

AI systems work in integration with IoT devices in hazardous industries to analyze environmental conditions and provide real-time alerts. AI-based systems used in the mining sector continuously monitor underground conditions, predicting potential risks such as collapses or gas leaks in advance (Dey et al., 2021). These technologies not only help prevent accidents but also improve operational efficiency. Indeed, several studies have shown that the use of AI-based systems can reduce the economic costs of workplace accidents by up to 30% (Smith & Johnson, 2022).

A report published by the Occupational Safety and Health Administration (OSHA) stated that AI-based safety applications significantly reduce legal violations in workplaces and financial losses resulting from workplace accidents (DOSH, 2023). In addition, these technologies enable employers to alleviate their legal responsibilities while strengthening employees' safety culture (Zhang et al., 2020).

However, the widespread adoption of AI-based occupational safety systems also raises ethical concerns regarding data privacy and employee monitoring. Continuous monitoring of employees can infringe on their right to privacy and indirectly negatively affect productivity by increasing stress levels in the workplace (Taylor, 2023). In this context, the proper implementation and regulation of such technology are of critical importance. For instance, the European Union's General Data Protection Regulation (GDPR) aims to limit the use of AI-based monitoring systems, ensuring their compliance with ethical standards (EU GDPR, 2018).

In conclusion, AI-based occupational safety systems offer significant advantages in protecting employee health, preventing accidents, and promoting a safety culture in workplaces. However, for these technologies to be implemented effectively, it is essential to act within the framework of legal regulations and ethical guidelines. In the future, with further advancements in these technologies, more comprehensive solutions in occupational safety are expected to emerge.

4. Ethics and Societal Impacts

4.1. Concerns About Automation and Job Loss

The integration of AI into the workforce has accelerated the spread of automation and increased concerns that machines may replace human labor in many sectors. A study conducted by the University of Oxford suggests that automation, particularly in industries with repetitive tasks, may lead to job losses in the short term. However, the same study also highlights that new job opportunities could emerge. For example, new fields of expertise are forming in the development and management of AI, which increases the need for workforce skill transformation (Frey & Osborne, 2017).

4.2. Widening Social Inequalities

The adoption of AI technologies also brings the risk of exacerbating social inequalities. While high-income countries and large corporations have easier access to AI technologies, the implementation of such technologies remains more limited in lower-income regions. This situation may result in uneven economic growth on a global scale. An article published by MIT demonstrates that companies with early access to these technologies rapidly increase their competitive advantage, placing small businesses at a disadvantage (Acemoglu & Restrepo, 2020).

4.3. Data Privacy and Security Issues

The necessity of large amounts of data for AI to function effectively raises concerns about data privacy. In particular, AI-based systems that monitor employee performance can lead to

significant ethical issues in cases of data breaches or misuse. An article published in the Harvard Business Review highlights that employee monitoring systems, due to a lack of transparency, can create an atmosphere of distrust in the workplace (Mateescu & Nguyen, 2019). Companies must adopt clear policies when implementing these systems and develop mechanisms to protect employee rights.

4.4. Algorithmic Bias and Discrimination

AI systems can reflect the biases inherent in the datasets they are trained on and may make discriminatory decisions. For example, algorithms used in human resources processes may perpetuate discrimination based on characteristics such as gender or ethnicity if trained on historically biased decisions. An article published in Nature emphasizes the importance of using more inclusive and diverse datasets to prevent such biases (Binns, 2018).

4.5. Development of Ethical Frameworks and the Role of Companies

To address the ethical issues posed by AI, companies must act within the framework of international norms and guidelines. The European Union's "Trustworthy AI" principles establish standards for ethical design and implementation, encouraging companies to adopt this technology responsibly (European Commission, 2021). For companies, prioritizing values such as transparency, accountability, and fairness in AI applications is critical to achieving long-term success.

Conclusion

Artificial Intelligence (AI) has brought about transformative changes in the business world. With its ability to increase efficiency, reduce costs, and provide innovative solutions, AI is reshaping the future of both companies and employees. However, it is equally important not to overlook the ethical and societal dimensions of this technology. To fully harness the potential of AI, companies, employees, and management must adopt this technology responsibly. In this context, understanding and preparing for the future impacts of AI will be one of the primary responsibilities of the business world.

AI has fundamentally transformed business operations, employee roles, and competitive dynamics within industries. While AI offers vast opportunities, the risks it poses must also be addressed carefully. Therefore, it is necessary to take strategic steps to comprehensively evaluate the effects of this technology on the business world and to manage its future potential effectively.

Through process automation and analytical capabilities, AI has enhanced business efficiency and accelerated the pace of innovation. Particularly in data-intensive industries, the use of AI has made decision-making processes faster and more accurate (McKinsey, 2023). Simultaneously, the reduction of repetitive tasks in the workforce has enabled employees to focus on more strategic and creative roles.

The impacts of AI have not been evenly distributed. While automation may cause job losses, it is also predicted to create new areas of employment. However, if this transformation is not

supported by education and skill development programs aimed at increasing workforce competencies, it may deepen social inequalities (Frey & Osborne, 2017). Additionally, issues such as data privacy, algorithmic neutrality, and ethical governance represent significant challenges in the adoption of AI (Binns, 2018).

The effects of AI vary across different sectors. For instance, AI applications based on data have achieved significant success in the finance and healthcare sectors, while in industries such as construction and agriculture, groundbreaking innovations have been introduced in terms of safety and operational efficiency. However, the sectoral adaptation of AI remains limited due to the accessibility and cost of this technology.

Preparing the workforce for the age of AI requires prioritizing education and reskilling programs. Greater emphasis must be placed on education in STEM (Science, Technology, Engineering, and Mathematics) fields, and lifelong learning opportunities should be provided for employees (Acemoglu & Restrepo, 2020).

To ensure the ethical use of AI applications, national and international standards must be established. Companies adopting principles of transparency will ensure that algorithmic decisions are explainable and fair. The European Union's "Trustworthy AI" guidelines serve as a notable example in this regard (European Commission, 2021).

The integration of AI into the workforce must be planned in an inclusive manner, covering all employee groups. Workforce transformation should be supported by fair transition mechanisms,

particularly for disadvantaged groups. Governments must play an active role in this process and develop social policies to regulate changes in labor markets.

It is essential that AI technologies are designed to work alongside human creativity and emotional intelligence. Rather than systems that completely replace humans, hybrid models that strengthen human-AI collaboration should be adopted. This approach will not only enhance employee engagement in the workplace but also optimize productivity (Mateescu & Nguyen, 2019).

The adoption of AI technologies by small and medium-sized enterprises (SMEs) should also be encouraged, alongside large corporations. To achieve this, low-cost and accessible AI solutions should be developed to ensure that economic growth is distributed more equitably.

AI has created a powerful wave of change in the business world, bringing both opportunities and risks. The rapid rise of this technology necessitates that organizations reassess not only their focus on efficiency and innovation but also their ethical, social, and environmental responsibilities. For the business world to thrive in this new era, it is crucial not only to adapt to technology but also to adopt a human-centered and ethical approach.

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CHAPTER V

Niche Areas in the Context of Competitive Strategies

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Introduction

In today's rapidly changing business world, it is of great importance for businesses to gain competitive advantage and make this advantage sustainable. Globalization, digitalization and the constant change in customer expectations are forcing businesses to reconsider their competitive strategies. While competition refers to the efforts of businesses in the same market segment to gain an advantage over each other, competitive strategies determine the ways to achieve and maintain this advantage. Strategic approaches such as cost leadership, differentiation and focus, defined by

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Michael Porter within the framework of competitive strategies, aim to provide businesses with competitive power in the market. In this context, niche markets, which have been met with increasing interest especially in recent years, offer businesses opportunities that appeal to a narrow and specific customer base with less competition.

Niche areas are narrow markets that respond to the specific demands of a specific target audience, unlike broad markets. While businesses that appeal to broad markets face intense competitive pressure, businesses that focus on niche areas may have the chance to compete among fewer competitors. For this reason, competitive strategies for businesses operating in niche markets exhibit a different structure compared to large-scale markets. Businesses competing in niche markets can gain competitive advantage by offering customized products or services to customers. Especially for SMEs and businesses with limited resources, niche markets offer a strategic option to compete with large competitors.

The purpose of this study is to reveal the strategic advantages that niche markets provide to businesses and to examine how they can develop successful competitive strategies in these areas. The study will address the ways in which competitive strategies are implemented in niche markets, the advantages they offer to businesses, and the potential risks in these areas. In this context, a review based on literature review will be conducted under the headings of competitive strategies, opportunities offered by niche areas, and how these opportunities should be evaluated.

This research is based on a compilation method that systematically compiles existing information in the literature and

analyzes past studies on the subject. In this direction, academic articles, books and sector reports written especially on competitive strategies and niche markets will be examined, and a theoretical framework will be created by considering case studies on successful competitive strategies. The reason for choosing this method is that it allows for a multi-faceted and comprehensive analysis of the factors affecting the competitive strategies of businesses.

The contribution of this study to the literature and the business world will be the systematic examination of the advantages and limitations offered by niche markets in terms of competitive strategies. The evaluations presented in the study have the potential to guide businesses operating in niche areas in their strategic planning. At the same time, strategic suggestions will be presented for SMEs that want to operate in niche areas to increase their competitive power.

1.Niche Areas in The Context of Competitive Strategies

A niche is a narrow niche in which a business specializes in a specific product or service within a specific market segment or industry. In this niche, the business differentiates itself from its competitors by focusing on the specific needs of its customers and offering products and services customized to meet those needs (Investopedia, 2024). For example, a coffee shop called First Class Coffee might target a niche market that prioritizes organic coffee producers and offers fresh, delicious coffee. This niche addresses the need for customers to support a healthier lifestyle or sustainable farming practice (Investopedia, 2024).

A niche can be used as a business strategy and can even be considered a competitive strategy. By specializing in a specific niche market, a business can offer differentiated products and services to differentiate itself from its competitors and meet the specific needs of customers (Harvard Business Review, 2024). For example, the automobile company Tesla specializes in a niche market in electric cars and differentiates itself from its competitors. The company fills this niche by offering high-quality, high-performance, and environmentally friendly electric cars, responding to customers' desire for an environmentally friendly alternative (Harvard Business Review, 2024).

Businesses use many strategies to compete, including pricing strategies, marketing strategies, innovation strategies, and customer relationship strategies (Besanko, Dranove, Shanley, & Schaefer, 2010; Kotler & Armstrong, 2010).

Pricing strategies enable businesses to gain competitive advantage by using pricing policies and tactics. These strategies include methods such as discounts, price comparisons, price differentiation, and price flexibility (Besanko et al., 2010; Kotler & Armstrong, 2010).

Marketing strategies are the tactics that businesses use to market their products and services. These strategies include advertising campaigns, promotions, market research, and target marketing (Aaker & Keller, 2012; Armstrong & Kotler, 2013).

Innovation strategies include the methods that businesses use to develop new products and services. These strategies include R&D

studies, product development processes, and innovative business models (Christensen, 2013; Chesbrough, 2010).

Customer relationship strategies include methods that businesses use to strengthen their relationships with their customers. These strategies include methods such as customer loyalty programs, customer service, and personalized services (Fournier & Avery, 2011; Reichheld & Sasser Jr., 1990).

Concentration strategies enable businesses to gain competitive advantage by focusing on their current activities. These strategies include methods such as focus, specialization and concentration (Porter, 1996; Prahalad & Hamel, 1990).

Differentiation strategies allow businesses to gain competitive advantage by using unique features and advantages. These strategies include methods such as unique product design, branding, quality and services (Levitt, 1980; Keller, 2003).

Low-cost strategies enable businesses to achieve competitive advantage by reducing costs. These strategies include increasing efficiency in production processes, using low-cost raw materials, and reducing product variety (Porter, 1985; Treacy & Wiersema, 1995).

businesses can use. Price, marketing, innovation, customer relations, concentration, differentiation and low cost strategies allow businesses to stand out from their competitors. Businesses that successfully implement these strategies can achieve greater market share, customer loyalty and higher profitability.

The competitive strategies of the companies vary depending on the company's goals and market conditions. Companies can gain

competitive advantage by using many strategies such as price, marketing, innovation, customer relations, concentration, differentiation and low cost strategies. However, in order to determine a successful strategy, the company must take into account its own conditions and strategic goals.

A niche is a small segment or market within a market or industry that offers a specific product or service that addresses a specific need or feature. They are often discovered by small businesses or startups that target a segment that larger companies or corporations have not targeted or have ignored.

These niches can better meet the needs of consumers and differentiate themselves from their competitors by offering products or services that are targeted to a specific market segment. For example, a cosmetics company may operate in a niche by offering products that are targeted to a specific market segment, such as vegan or organic products.

Focusing on niches can increase a business's competitive advantage and allow them to operate in a less competitive market. However, when niched, the number of potential customers is smaller, so businesses may need to adjust their marketing strategies accordingly.

2.Finding a Niche and Competition

Finding niches can increase a company's competitive advantage because niches are generally less competitive. Niche markets are discovered by small businesses or startups that target a small segment that large companies do not target or ignore (Kotler

& Armstrong, 2017). A company's focus on a niche can reduce competition and differentiate itself from its competitors. A company operating in niche areas can better understand its potential customer base, offer products and services that are more suitable for customer needs, and better meet customer expectations (Porter, 1985).

This can increase customer loyalty and give the business a positive image (Aaker, 2012). In addition, a business operating in a niche area can reach its target customer base more effectively with lower marketing costs (Levitt, 1980). However, operating in a niche area means that businesses have fewer potential customers. Therefore, it is important for businesses to conduct good niche market research, understand the size of niche markets and the number of potential customers, and determine their marketing strategies accordingly (Christensen, 2013).

The fact that a business operates in a niche does not mean that it should make an investment decision immediately. When operating in niche areas, businesses must first understand the size of niche markets, the number of potential customers, the competition situation, and the needs and expectations of consumers (Kotler & Keller, 2016). When operating in niche markets, businesses should determine the size of the market and potential opportunities by conducting comprehensive research on the purchasing behaviors of potential customers and market trends (Lamb, Hair, & McDaniel, 2018). In addition, businesses need to determine their marketing strategies accordingly when operating in a niche area (Porter, 1985).

Once a business starts operating in a niche area, it is necessary to regularly monitor and evaluate the performance and

efficiency of the business (David & David, 2017). When operating in niche markets, it is important for the business to make a good analysis before making a decision and to consider factors such as the size of the market, the number of potential customers, the competition situation and customer needs (Aaker, 2012).

niche areas may present potential opportunities for businesses; however, businesses need to be careful and conduct good research when entering these markets (Day & Moorman, 2010). Once a business begins operating in a niche area, it is also important for it to regularly monitor and evaluate its performance and adjust its strategies accordingly (Porter, 1996).

A business can use the following methods to find their niche:

Market Research: By conducting market research, a business can learn about the needs and demands of its customers. Market research can provide opportunities to discover a niche that customers may not have previously noticed.

Monitoring and Analysis: By monitoring its competitors, a business can learn about their business model, customers, and services. This information can give the business the opportunity to explore a niche that its competitors have overlooked.

Own Creativity: Business management can try to explore different niche areas by generating creative and innovative ideas. This method gives the opportunity to discover a niche area where the business can offer special services to the customer while maintaining its originality.

Collaboration: By collaborating with other businesses, a business can explore a niche that will better meet customer needs. Collaboration provides an opportunity for other businesses to expand their customer base and target new customers.

Internet Research: The internet is a resource for discovering many niche areas and customer needs. By conducting internet research, the business can discover new niche areas according to the needs and expectations of the customers.

Customer Feedback: By getting feedback from its customers, the business can create opportunities to understand customer needs and explore new niche areas.

Businesses can discover niches by understanding customer needs and demands using methods such as market research, competitor monitoring, creativity, collaboration, internet research and customer feedback. By using these methods to find their niches, businesses may be able to develop differentiation strategies.

Market research is an important step for businesses to understand customer needs and market trends. Businesses can use the following methods to find their niche:

Target Audience Analysis: By determining their target audience, businesses can understand the needs and demands of their target audience. Target audience analysis will help businesses better understand customer needs.

Competitor Analysis: By researching their competitors, businesses can learn about their competitors' products, services, and

customer service. Competitor analysis can help businesses discover a niche that their competitors have overlooked.

Surveys and Focus Groups: Businesses can learn about customer needs and demands through surveys and focus groups. This method can help businesses discover a niche that customers may not have previously noticed.

Social media: Businesses can understand customer needs by tracking customer opinions and feedback through social media platforms. Social media can help businesses understand customer needs and demands better.

Research Reports: Businesses can understand industry trends and market tendencies through research reports. Research reports can help businesses explore new niches based on customer needs.

Internal Research: Using their own data, businesses can understand customer needs and demands. Internal research can help businesses explore new niches based on customer needs.

Businesses can understand customer needs and market trends using methods such as audience analysis, competitor analysis, surveys and focus groups, social media, research reports and internal research.

3.Niche Area Strategies of Businesses

Business niche strategies require careful planning and implementation in terms of marketing and business management.

When operating in a niche, businesses can consider the following strategies:

- Market Analysis: Businesses must first conduct detailed research on niche markets. This research should be done to understand the size of the niche market, the competition situation, the number of potential customers and customer needs. Market analysis can help businesses identify opportunities in the niche market and understand customer needs.
- Customer Focus: Businesses operating in a niche need to focus on understanding customer needs and responding to customer expectations. A customer-focused strategy can help businesses build customer loyalty in a niche market.
- Differentiation: Businesses need to offer unique products and services to create differentiation in a niche area. A differentiation strategy can help businesses differentiate themselves from their competitors in a niche market.
- Collaboration: When operating in a niche, businesses can work together with other businesses through partnerships and collaboration. Collaboration can help businesses gain a competitive advantage in a niche market.
- Marketing Strategies: When operating in a niche area, businesses need to plan their marketing strategies in accordance with the characteristics of the niche market. Marketing strategies can help businesses create awareness in the niche market, build customer loyalty and increase sales.
- Innovation: Businesses operating in a niche need to continually innovate and offer innovative products and services. Innovation can help businesses gain a competitive advantage in a niche market and increase growth potential.

Understanding customer needs, differentiating, collaborating, customizing marketing strategies, and innovating. Businesses operating in a niche area can gain a competitive advantage by serving a specific customer base that they will focus on, while offering unique products and services to meet the needs of this group.

However, it is important to remember that businesses need to conduct market analysis before implementing niche strategies. Although niche markets are targeted to a specific customer base, they also come with certain risks. To avoid these risks, businesses need to understand the opportunities and potential challenges that can exist in a niche market.

A business that wants to operate in a niche can provide growth and competitive advantages. However, these advantages depend on the business understanding the market and customers, creating differentiation, collaborating and innovating.

Many businesses have achieved great success with niche strategies. One of these is ModCloth, a company founded in the United States and operating in the online clothing industry. ModCloth has created a niche market focused on retro clothing style (Peterson & Simon, 2016).

ModCloth has gained a competitive advantage by offering unique clothing products to its target audience. At the same time, it has developed its products and customized its marketing strategies by taking into account the feedback of its customers to understand their needs (Lewis, 2017). Thanks to these strategies, ModCloth has

achieved great success in its niche market and was acquired by Walmart in 2017 (Robinson, 2018).

4.Niche Success and Competitive Advantage

By operating in a specific niche, businesses can focus on a narrower customer base. This customer base usually addresses a specific need or demand, and because competition is less intense in larger markets, businesses are more likely to succeed in that market (Kotler & Keller, 2016).

In addition, businesses operating in niche areas can differentiate themselves by offering a unique product or service. This can provide a competitive advantage. When customers are looking for a unique product or service, they may prefer businesses in these niche markets (Porter, 1985). Businesses operating in niche areas can also provide a more customized service by better understanding customer needs. This can increase customer satisfaction, create customer loyalty, and provide a competitive advantage in the long run (Aaker, 1991).

Businesses operating in niche areas can gain competitive advantage by focusing on a narrower customer base, differentiating themselves, and meeting customer needs. However, it is important for businesses to conduct market analyses, understand the opportunities and risks that may exist in their niche markets, and develop their strategies accordingly (Day, 1994).

5.Strategic Applications Related to Niche Areas

Conduct Market Research: Conduct market research to identify niches within the industry your business is interested in. Examine current competitors, understand market needs and demands, and identify potential customer segments. These steps can increase your business's likelihood of succeeding in a potential niche market.

Understand Customer Needs: Businesses operating in niche markets can conduct marketing research to better understand customer needs. Customer feedback and data can be used to customize products and increase customer satisfaction.

Differentiate: Niches allow businesses to offer a unique product or service. By differentiating your business, you can set yourself apart from your competitors and gain a competitive advantage. To do this, you can stand out by customizing your products to customer needs or by differentiating your services.

Customize Your Marketing Strategy: Businesses operating in niche markets can reach their target audience more effectively by customizing their marketing strategies to the niche market. This can be used to attract customers by marketing with the right messages, on the right channels, and at the right time.

Build Partnerships: Businesses operating in niche markets can reach a broader customer base by building partnerships. This can be accomplished through partnerships with other businesses in the industry, profit sharing, or another type of collaborative agreement.

Continuously Improve: In the niche market that your business operates in, customer needs and demands may change.

Therefore, your business should continuously improve so that it can react quickly to changes in the market.

6.Strategic Planning and Applications Related to Niche Areas

Identifying niche markets: First, niche markets need to be identified. This requires businesses to decide which niches they want to operate in. Niche markets are areas where customers need a specific product or service, but that product or service is not met by the wider market.

Identifying target customers: Businesses need to identify the customer profiles they are targeting in niche markets. This involves determining what customer needs the product or service meets and which customers need that product or service.

Product or service development: Businesses may need to develop specialized products or services to operate in niche markets. This requires developing and delivering customized products or services to meet specific customer needs.

Marketing strategies: Businesses may need to develop specific marketing strategies to operate in niche markets. These strategies include where to find target customers, how to reach them, and what channels to use.

Cost-effectiveness: Businesses may need to achieve cost-efficiency to operate in niche markets. This requires optimizing manufacturing processes, improving supply chain management, and implementing other cost-saving measures.

Innovation: Businesses may need to continually innovate to maintain a competitive advantage in niche markets. This involves continually improving and developing products or services.

Flexibility: Operating in niche markets can require a dependency on a particular product or service, so it's important for businesses to be flexible and able to adapt to changing customer needs.

Another strategic planning step for businesses implementing a niche strategy is niche marketing strategies. Niche marketing strategies aim to gain competitive advantage by offering products and services specific to the niche market segments targeted by the business.

A niche marketing strategy is a strategy that appeals to smaller, specific markets rather than broad audiences. In these markets, businesses can gain customers by providing better service than their competitors, offering more special and unique products, providing a more personalized service, and more effective marketing communications.

Niche marketing strategies often require efficient use of marketing budgets. Therefore, businesses implementing niche marketing strategies must reach their target audience using the right marketing tools, attract customers with an effective message, and gain customer loyalty.

For example, there are many restaurant chains around the world. However, one of them, Subway, implements a niche marketing strategy by offering healthy and low-calorie foods, especially for customers who are sensitive about healthy eating.

Thanks to this strategy, Subway has managed to differentiate itself from its competitors in this area.

Niche strategy and niche marketing strategy, when implemented correctly, can help businesses gain a competitive advantage. However, proper market research, accurate target audience determination and use of the right marketing tools are important in implementing the strategies.

Conclusion and Evaluation

This study details how businesses can gain competitive advantage and achieve sustainable success by adopting niche market strategies. The study emphasizes that focusing on niche markets provides a more unique competitive advantage, especially for SMEs, compared to traditional broad market strategies. Instead of competing with large competitors in broad markets, SMEs can increase brand loyalty and provide more customized services by focusing on a specific customer segment (Aaker & Keller, 2012). This situation offers a valuable strategic opportunity for businesses that want to create a unique position in the market.

The study also touched upon issues such as resource limitations, lack of brand awareness, and barriers to entry that businesses entering niche markets face. In particular, the importance of establishing closer relationships with customers and being sensitive to customer feedback in order to overcome these barriers was emphasized. The successful examples analyzed in the study show that businesses gain competitive advantage by correctly understanding customer needs and offering them special solutions

(Day & Moorman, 2010). This situation reveals the importance of businesses constantly monitoring consumer expectations and shaping their strategies according to these expectations.

The study, which draws attention to the critical role played by technology in the success of niche market strategies, emphasizes that digital platforms provide businesses with the opportunity to reach small customer groups and offer special products or services to their target audiences. Tools such as social media and data analytics, in particular, allow businesses to understand customer behavior more deeply and adapt their marketing strategies more effectively (Armstrong Kotler, 2013). Thanks to digitalization, businesses operating in niche markets can establish trust and long-term loyalty by communicating directly with their customers.

Finally, the literature review included in the study shows that businesses operating in niche markets are generally more innovative and flexible. These businesses have the advantage of capturing opportunities that large competitors cannot see because they have the capacity to adapt quickly to changing market conditions. It has been concluded that businesses operating in niche areas can maintain their strong positions in the market by increasing their strategic flexibility and offering innovative solutions (Chesbrough, 2010; Porter, 1996).

In general, this study reveals that going beyond general competitive strategies and focusing on niche markets can be an effective method for creating competitive advantage. These strategies, which are especially valuable for SMEs, have the potential to achieve a sustainable competitive advantage based on specialized services and sensitivity to customer ne

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CHAPTER VI

Open-Source Intelligence As The Security Approach Of The 21st Century

Zafer AYAZ[1]

1. INTRODUCTION

Open-source intelligence (OSINT) is an intelligence method that aims to access information using open sources from a large data ecosystem. These resources cover various areas such as websites, social media platforms, public databases, media content, and academic publications. OSINT has become a widespread application that supports strategic decision-making processes in various industries and the public sector (Hulnick, 2002a).

As San Tzu says in The Art of War, "know your enemy and know yourselves; You do not have to be afraid of the outcome of hundreds of battles". OSINT tools allow cyber attackers to collect

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victim information without active interaction. From a defender's standpoint, open-source threat intelligence can be used to identify attackers. However, OSINT tools can also serve as a defensive measure, helping map information disclosures by attackers to safeguard the defender's security (Yamin et al., 2022).

OSINT, which has many definitions, is generally defined as "intelligence based on the analysis of non-confidential, publicly available information" (Heather and Blum, 2018, p:ix-x; Hulnick, 2002b). This definition emphasizes that OSINT's focus solely on publicly available information sets it apart from other types of intelligence. In another source, OSINT is defined as the collection and use of information from publicly available sources in a methodological manner to meet an intelligence requirement. This definition considers OSINT to be an aggregation discipline, explicitly does not include analysis and dissemination, and does not perceive OSINT as a final product as proposed (Block, 2024).

OSINT is an information gathering and analysis system that leverages public information from social networking services (SNS), playing a crucial role in the fight against terrorism and cyberterrorism. Responding effectively requires recognizing the information collected about terrorism in the real world. Therefore, awareness of terrorism is the most critical stage, with victims, witnesses, and law enforcement officers being vital in identifying it. However, recognizing terrorism and cyberterrorism in the digital realm is challenging, as reports from victims and witnesses are often insufficient for detecting attacks. While direct patrols in cyberspace, as in the physical world, are impossible, cyberspace can be

monitored through information gathering using OSINT technology (Lee et al., 2022).

Currently, OSINT, which refers to information from publicly available sources, constitutes between 80% and 90% of all intelligence activities conducted by Law Enforcement Agencies (LEAs) and intelligence services in Western countries. Advances in data mining, machine learning, visual forensics, and, most notably, the increased computing power available for commercial use, have empowered OSINT practitioners to expedite and, in some cases, automate the process of intelligence gathering and analysis, allowing for faster and more accurate results (Ghioni et al., 2024).

This research aims to create a resource that can be a bedside guide on the subject based on a comprehensive compilation of "Open-Source Intelligence (OSINT)" and present it to the benefit of readers.

2. HISTORICAL DEVELOPMENT OF OSINT

Although OSINT is not a new concept in intelligence operations, intelligence agencies gathered OSINT offline by monitoring newspapers and radio broadcasts to obtain crucial information before the World Wide Web. One of the earliest efforts to systematically utilize OSINT was the creation of the BBC Monitoring Service in the United Kingdom in 1939 (Block, 2024) and the United States in 1941 during the Second World War, the Foreign Broadcast Information Service (FBIS) to monitor public broadcasts from hostile countries (Browne et al., 2024).

With the development and spread of the Internet, the nature of publicly accessible information has evolved, leading some to

suggest that we are now in the second generation of OSINT. In the 1990s, when Robert Steele coined the term OSINT, practitioners recognized that the advent of personal computing could have a profound impact on intelligence gathering (Block, 2024). However, it can be said that the beginning of the second phase of OSINT was actually in 2005. In this evolving Internet era, much of the online content transitioned to dynamic web pages, user-generated content, and social media, marking the rise of what is known as Web 2.0. Social media platforms such as Facebook, YouTube, and Twitter (now X) were launched in 2004 and after that, embodying this shift (Heather and Blum, 2018, p:1-4).

By the turn of the century, the landscape had undergone significant transformation. The creation of the Open-Source Center (OSC) in 2005, which replaced FBIS in the U.S., signaled the onset of the second generation of OSINT. This new era was primarily driven by the digital revolution and the shift from "*classical*" to "*digital*" OSINT, which introduced powerful, previously unimaginable tools. These innovations can be broadly categorized into four main groups: linguistic and text-based, geographical, network-based, and visual forensics (Ghioni et al., 2024).

OSINT can be collected from multiple online sources, including social media, search engines, websites, online forums, company directories, and online databases. OSINT exhibits a different structure from traditional intelligence methods that require access to classified and limited information. The rise of the internet and social media has made OSINT more complex in terms of resources and methods. Therefore, it is argued that this should be seen as the era of second-generation OSINT (Heather and Blum,

2018, p:1-4). Today, the large dimensions and complex structure of the data collected can lead to difficulties in classifying, categorizing, and extracting meanings. Recent developments show that artificial intelligence and machine learning applications benefit from this issue (Browne et al., 2024).

3. OSINT'S ROLE IN MODERN SECURITY AND INTELLIGENCE

OSINT has become one of the most fundamental components of security strategies today. It is actively used in monitoring cyber threats, border security, and terrorist activities and stands out as a real-time and practical source of information in these areas. Events like the Iranian Green Revolution in 2009, for instance, vividly demonstrated how new forms of social media can offer real-time intelligence in environments where traditional access is restricted (Heather and Blum, 2018, p:1-4).

Using cross-data connectivity, OSINT methods can infer intelligence from a vast data ecosystem. As the data network on the Internet expands, the effectiveness of OSINT increases, and various data from different sources are transformed into meaningful information. Governments, military defense, and the private sector have long used OSINT in defense, competitive advantage, and strategic decision-making. In addition, OSINT plays a critical role in monitoring and analyzing this information in various activities carried out by internet users within the legal framework (Eksim & Kara, 2019).

Whether OSINT should be considered an intelligence discipline is debatable; some argue that OSINT is not a discipline

because it is not secretly assembled, while others state that OSINT is an aspect of other intelligence disciplines. Geospatial Intelligence (GEOINT) is increasingly becoming OSINT because commercial satellites now offer an aerial imaging capability equal to that provided by classified collection platforms alone. Commercial satellites can be used in military and civilian applications by providing high-resolution images. Derived from social media, OSINT can be considered a type of Human Intelligence (HUMINT) and Signals Intelligence (SIGINT). Information on the Internet is becoming increasingly secure, making OSINT challenging to obtain through open-source collection methods (Heather and Blum, 2018, p:7-8).

Low cost, variety, and legality are the features that make this method attractive. For this reason, various actors, such as states, international organizations, companies, terrorist organizations, and law enforcement agencies, use OSINT. OSINT is an integral part of the data collection and analysis process, and studies in this area are increasing with technological advancements. The open-source collection contributes to the intelligence cycle's collection, evaluation, and analysis phases. At the same time, it is seen as a process that supports individuals' access to information with the understanding of an open society (Çıtlak, 2021).

Open-source data often has limited value when examined individually but gains significant intelligence value when aggregated. For instance, a single tweet expressing an individual's view on the Islamic State of Iraq and the Levant (ISIS) holds little intelligence value; however, analyzing tweets on ISIS opinions within a specific region can yield valuable insights. Similarly, while

a single IP address has minimal intelligence value, mapping all 4.3 billion IP addresses worldwide can offer a comprehensive view of global Internet usage (Heather and Blum, 2018, p:7-8).

The OSINT process involves three main phases: data collection, enrichment, and knowledge extraction. With the widespread use of the internet and social media platforms, the volume of information circulating online is constantly increasing. As a result, the intelligence extraction process must operate iteratively, handling the continuous data flow. The process begins with data collection, enrichment, and knowledge extraction, which then loops back to the initial stage and repeats cyclically. The feedback from the extracted information can be compared to the original data collection parameters. Ultimately, new parameters are established and adjusted in response to the evolving content on the internet. When applied to the fight against terrorism, OSINT extraction techniques can be used to analyze data from sources categorized as:

(i) Informative Sources: To have reliable information about terrorism-related events, i.e., online newspapers, reports, and available databases.

(ii) Active Sources: Real-time streaming content from platforms like social media, websites, blogs, and discussion forums often contains posts that incite extremism, radicalization, and unrest within online communities, particularly in relation to terrorist events and propaganda. Radical content plays a pivotal role in transforming individuals, while extremism refers to the extreme beliefs that emerge as a result of radicalization, which can take social, political, religious, or other forms. This review focuses on social media

content related to terrorism, where radicalization and extremism are prevalent. Although there are sources like the LuckyTrollClub dataset, which identified ISIS-related accounts using crowdsourced data from Twitter, there is no comprehensive knowledge base integrating information from multiple active and informative sources. The review highlights that terrorist incidents create chaos on the internet, both before and after they occur, making it essential to consider both active and informative sources of information. In addition to providing informational value, these incidents also have social media implications that can help predict public unrest and identify online influencers of terrorism. **Figure 1** details the three stages of the OSINT information extraction process. The research studies and elements carried out at each stage have been extensively examined in the following chapters (Chaudhary & Bansal, 2021).

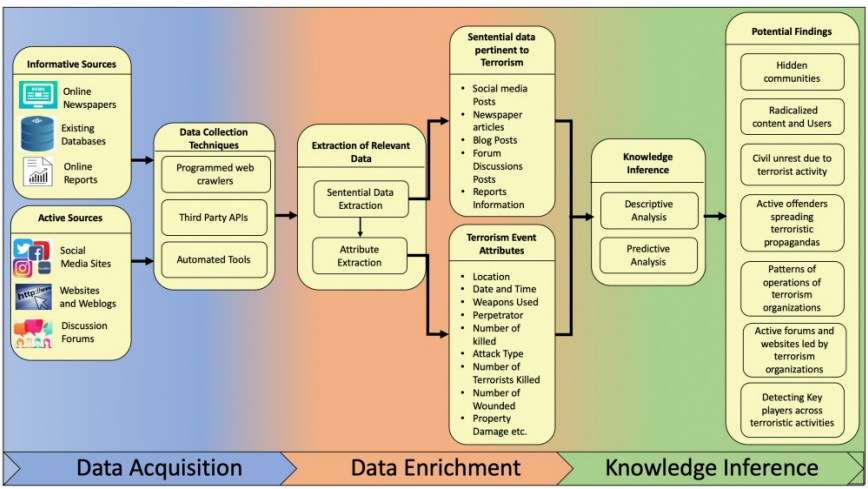

Figure 1. *The Use of OSINT Processes in Combating Terrorism (Chaudhary & Bansal, 2022)*

4. BASIC CONCEPTS OF OSINT

A significant portion of the literature on OSINT focuses on establishing a clear definition. This is challenging because intelligence analysis remains a topic of debate in the relevant literature. Different authors and organizations propose varying definitions, and any OSINT definition must consider the ongoing advancements in computer science, data science, and artificial intelligence, which continuously enhance the capabilities of intelligence gathering and analysis (Ghioni et al., 2024). In one of these definitions, OSINT is defined as: "intelligence based on the analysis of non-confidential, publicly available information" (Heather and Blum, 2018, p:ix-x; Hulnick, 2002b).

Open sources are examined in two groups: offline and online. In contrast to offline resources such as newspapers, magazines, and conference publications, online resources such as social media and blogs are also available. The data collected from these sources can be used as raw data or intelligence products. Open sources consist of official government data and social media content of questionable accuracy. In its 2001 Open-Source Intelligence Handbook, NATO defined open-source intelligence as information processed and distributed to a specific question. Open-source intelligence was initially seen as a tool to support other types of intelligence, but over time, it has become a discipline in its own right (Çıtlak, 2021).

Open-source data includes publicly available material, such as commercial satellite imagery, that has not been explicitly published but is still in the public domain or commercially available (Heather and Blum, 2018, p:7-8).

Grey literature, on the other hand, encompasses a variety of non-commercially produced sources, such as technical reports, working papers, business documents, and conference proceedings. Intelligence agencies have long used grey literature to provide strategic insights and support operational decisions. Despite advances in electronic collection methods, the collection of grey literature, especially in areas with low information availability and limited digital infrastructure, may sometimes require a physical presence. The classification of gray literature within OSINT creates difficulties by blurring the boundaries between HUMINT and OSINT (Serscikov, 2024).

OSINT methods are capable of establishing data-to-data connections. In this respect, it does not limit itself by converting data into information only within certain limits. On the contrary, it considers borders to be any data on the internet network. In addition, as technology develops and the information network expands, OSINT will continue to be even more effective. Thus, a wide variety of data that seems utterly irrelevant on the internet can be filtered by intelligence techniques and appear as intelligence information (Eksim & Kara, 2019).

Critical for managers and decision-makers is up-to-date and quickly accessible intelligence. It is important to inform these people with short and direct explanations in between their busy schedules, especially in the morning. This type of intelligence primarily uses open sources with a dynamic structure. The fact that it can be done within the legal framework, flexible system requirements, and the ability to obtain it from the market distinguishes open-source intelligence from other collection methods. The development of

open-source intelligence has reached a new dimension with the opening of the internet to the public. The proliferation of web pages, blogs, social media, and open-access databases offers ample possibilities for intelligence. The influence of social media creates a rich pool of social data, including various data such as geolocation, shopping preferences, likes, and articles. These sources provide information in many fields, including military, political, economic, cultural, and scientific. However, this diversity and volume of data bring challenges and opportunities in intelligence-gathering activities (Çıtak, 2021).

Source of Open-Source Information (OSIF.) is only publicly available unclassified data; OSINT, on the other hand, is obtained by processing and using the information to verify that it is relevant, accurate, and actionable for use by consumers (Heather and Blum, 2018, p:7-8). The abbreviations in **Figure 2** show schematically the relationships between OSINT and OSINT.

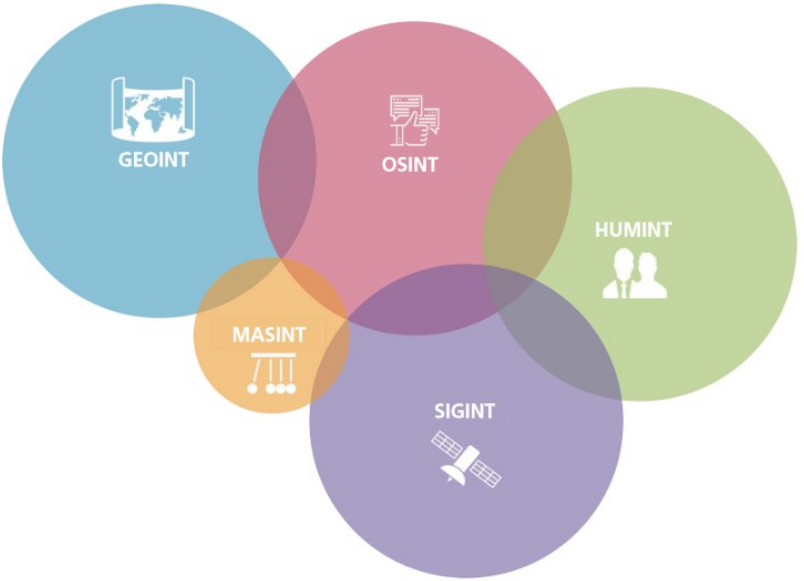

Figure 2. *OSINT and Other Interdisciplinary Connections (Heather and Blum, 2018, p:7-8)*

The role of OSINT in international security is essential not only at the national level but also at the regional and global levels. OSINT accelerates the process of obtaining intelligence in times of crisis and supports time-sensitive decision-making mechanisms, as it provides a rapid flow of information (Best & Cumming, 2007). Another important point made by Hulnick (2002a) is that OSINT is based on people-based knowledge. This provides an effective strategy for understanding local security threats. **Figure 3** shows a schematic representation of the systematics called the OSINT operation cycle (Heather and Blum, 2018, p:12-14).

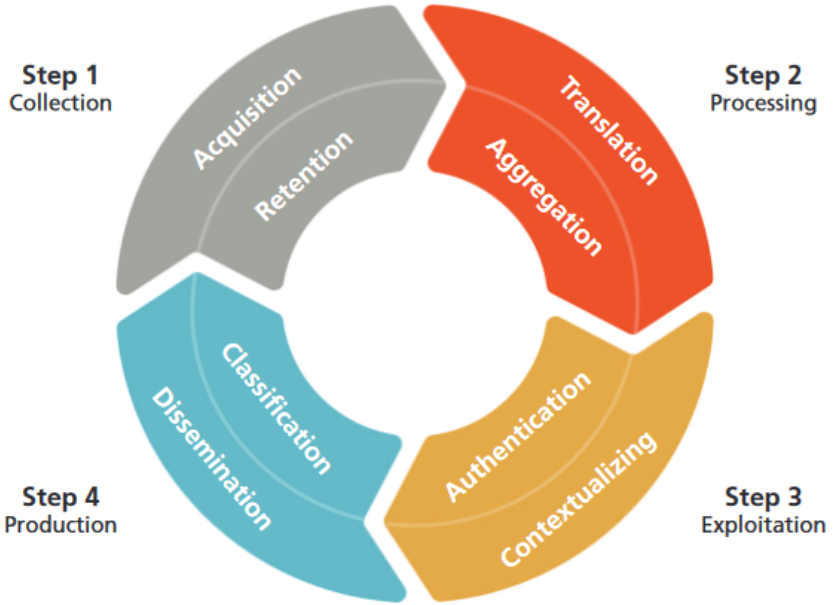

Figure 3. *OSINT Operation Cycle (Heather and Blum, 2018, p:12-14)*

According to the OSINT operation cycle systematics, operations are carried out under the main headings of Step 1: Collection, Step 2: Processing, Step 3: Use, and Step 4: Production. In the sub-headings of these processes, there are detailed sub-processes such as Acquisition, Storage, Collection, Translation, Classification, Dissemination, Authentication, and Contextualization. **Figure 4** shows the open source in which these processes are included and the difficulty levels of the analysis processes within them (Heather and Blum, 2018, p:12-14).

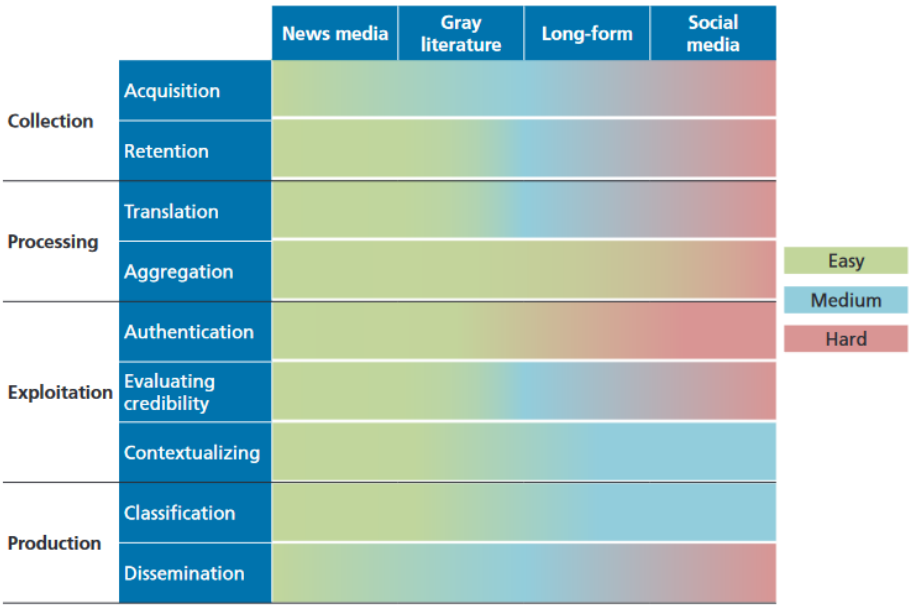

Figure 4. *OSINT Operation Cycle Sub-Processes Area-Difficulty Table (Heather and Blum, 2018, p:12-14)*

5. CURRENT ACADEMIC STUDIES ON OSINT

The two countries that dominate academic studies are the United States and India, which contribute 44% of the total, corresponding to most existing studies. The United Kingdom and China also follow the two leading countries in this field. Research papers by these top four countries account for approximately 57% (Browne et al., 2024). OSINT is being treated with increasing interest in the academic field. Studies on OSINT in different disciplines, such as security studies, information systems, and media research, reveal the multifaceted structure of this concept. This article discusses the differences and limitations of OSINT from

traditional intelligence. The role of OSINT in the security and military sphere is analyzed by Hulnick (2002b).

The report, prepared by Best and Cumming, is a study prepared for the U.S. Congress and describes the advantages, limitations, and legal aspects of OSINT. The report highlights and discusses the importance of OSINT, particularly in the context of security and national policymaking (Best and Cumming, 2007).

In a study conducted by Arslan and Yanık, it was stated that the rapid rise of social media has changed communication habits and allowed users to express themselves freely. It has been stated that these user-generated contents provide intelligence personnel with access to information that may be difficult to obtain through direct inquiries. Therefore, they are a valuable resource for social media data mining in terms of Open-Source Intelligence (OSINT) (Arslan & Yanık, 2015).

In a study conducted by Ekşim and Civelek, it was stated that OSINT is the discipline of producing intelligence from the information obtained by systematically collecting, processing, and analyzing publicly available information, and social media is used as a fast and practical resource for the detection of zero-day attacks and the prevention of cyber-attacks. The authors propose a semi-automated OSINT-based intrusion prevention model that is activated by intelligence obtained through social media (Ekşim & Civelek, 2019).

In a study by Eksim and Kara, it was stated that the increasing impact of cybercrime has made OSINT an essential tool in the fight against cybercrime by collecting and analyzing open data on the

internet, as intelligence and law enforcement agencies around the world increase their efforts to combat these threats. In this study, existing methods and research related to the role of OSINT in cyber-attack detection and prevention were examined in detail, and a cybercrime investigation framework was proposed (Eksim & Kara, 2019).

A study by Tiryaki and Özdal emphasized that social media had become an essential source of open-source intelligence for government agencies, commercial companies, and other actors. It was reported that the study aimed to analyze the potential benefits of big data obtained from social media in various fields (Tiryaki & Özdal, 2020).

In a study conducted by Çıtak, it was emphasized that terrorism is one of the most critical security issues today, and the fight against terrorist organizations poses a severe problem. This study aims to contribute to the Turkish literature by discussing the role of open-source intelligence in the fight against terrorism and its advantages in collection activities (Çıtak, 2021).

In a study conducted by Erol, it is argued that OSINT provides essential support to intelligence analysts and decision-makers by using information obtained from different sources, that OSINT is not used enough in military intelligence, and that appropriate processes and methods are lacking in its current usage areas. In addition, it has been emphasized that OSINT can be a valuable discipline for military intelligence if used appropriately and in coordination with other intelligence disciplines (Erol, 2022).

In a study by Lee et al., it was stated that OSINT is a critical information-gathering activity in the fight against terrorism and cyberterrorism by using publicly available information in social networking services. This study presents OSINT analysis activities and tools related to military information leakage, and the results of 100,209 military information keyword searches and 471 name search cases are shared. In addition, it has been stated that personally identifiable information is not sought due to the strengthening of personal information protection (Lee et al., 2022).

In a study by Zang et al., it was stated that more and more industrial devices and critical infrastructure (CIs) are connected to the internet to manage and operate industrial production efficiently, and they are exposed to attacks by malicious hackers and cyber terrorists. The study investigates OSINT data that malicious actors can use to carry out cyberattacks against the CI sector and determines the data types. Results from searches conducted on four open-source platforms (Google, YouTube, Reddit, and Shodan) between 2015 and 2020 were examined, and three main data types were identified: thematic content analysis and indirect discovery data, proof-of-concept codes, and training materials (Zhang et al., 2022).

In a study conducted by Çağlak, it was stated that the Directorate of Printing and Intelligence made significant contributions with propaganda and news-gathering activities during the National Struggle and that the Directorate analyzed the information obtained from open and closed sources and conveyed this information to the relevant official institutions. These studies have been compiled and provided valuable data for Turkish political decision-makers (Çağlak, 2023).

In a study conducted by Dağdeviren and Kedikli, it was reported that states use methods such as Human Intelligence, Open-Source Intelligence, and Technical Intelligence in the fight against internal and external security threats. The study analyzed the intelligence structures and methods used by the UK, USA, Israel, and Turkey (Dağdeviren & Kedikli, 2023).

In a study conducted by Ökten, it was aimed to discuss the role of open sources in intelligence studies and the main topics in this field, as well as to contribute to the process of creating Turkish terminology by addressing issues such as the democratization of intelligence, the aggregation-analysis duality, and the strengths and weaknesses of open sources (Ökten, 2023).

In a study by Sezgin and Boyacı, a model was proposed to obtain cyber security intelligence by converting raw data from social media and cyber security sites into structured data. It has been reported that the proposed model structures raw data and brings it into standard forms that can feed cybersecurity software (Sezgin & Boyacı, 2023).

A study by Taban and Aydilek focuses on the transformation of intelligence analysis in the digital age and examines the implications of new analysis methods. Intelligence communities address issues such as data mining, algorithm development, and supporting the human element with digital innovations to cope with the changing threat climate and technological developments (Taban & Aydilek, 2023).

In a study conducted by Bural, examples are revealed that posts made by soldiers on social media can be turned into

intelligence by adversaries and threaten the security of military operations. In addition, training, information, and legal sanctions are recommended to prevent posts that violate operational security (Bural, 2024).

In a study by Ghioni et al., OSINT accounts for a large part of the activities of law enforcement and intelligence services in the West. Technologies such as data mining and machine learning enable OSINT to be collected and analyzed more quickly and accurately. The related article examines the governance, ethical, legal, and social implications of AI-powered OSINT, assessing gaps in the existing literature and new research directions (Ghioni et al., 2024).

A study by Yang et al. showed that the GPT-4-based GeoLocator model can extract location information from images and social media content with high precision, leading to geographic privacy violations. Protecting geographic privacy is critical to maintaining ethical standards in personal security and geoscientific practices, and the implications of GeoLocator highlight the need for increased awareness and protective measures in the context of geographic privacy (Yang et al., 2024).

A study by Van der Woude stated that with the increasing accessibility of online data, digital open-source research (OSINV) methods are becoming increasingly popular in journalism. However, it was emphasized that new challenges have arisen between journalists' ideals of transparency and their duty to protect the privacy and security of data subjects. This study explores the complexities of open-source investigative (OSINV) journalism and

the delicate balance between journalistic transparency and privacy/security considerations based on eight in-depth interviews with professional open-source investigative journalists in the Netherlands (van der Woude et al., 2024).

6. ANALYSIS METHODS AND TOOLS USED FOR OSINT

Increasing digitalization can add a new platform to the daily list of open data sources. For this reason, an analysis method and vehicle description may lose their validity after a while. In this context, there are some valuable sources of information. One of them is the website called OSINT Framework. **Figure 5** shows some analysis methods and tools this site has compiled. This initiative aims to help people find free OSINT resources by focusing on gathering information from free tools or sources. It is emphasized that some sites included may require registration or offer more data for a fee, but some sources can obtain at least some of the available information for free. Each node, expressed in blue, has sub-details open when clicked (OSINTFramework, 2024).

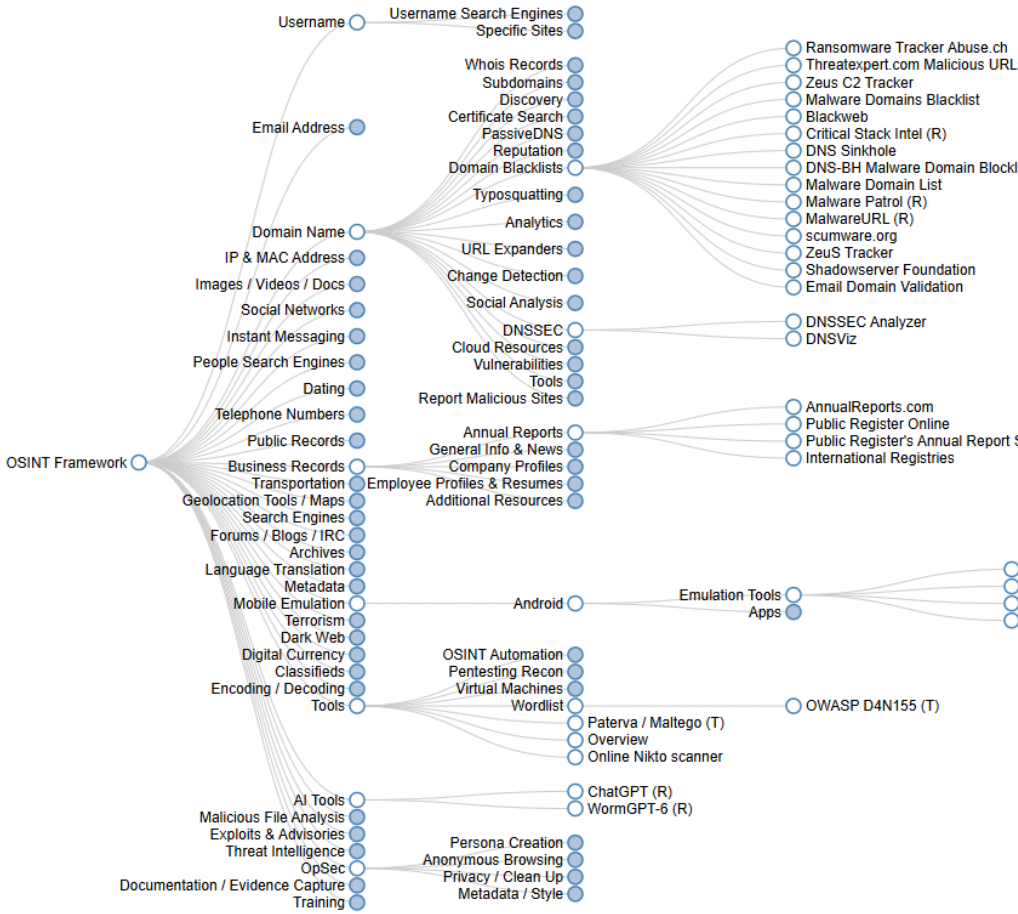

Figure 5. *OSINT Framework Table (OSINTFramework, 2024)*

However, in a report prepared by Heather and Blum for the RAND Corporation, the following analysis methods are explained in detail (Heather and Blum, 2018, p:21-35):

6.1. Methods Used in Social Media Content Analysis

While OSINT collection tools are rapidly evolving, the methods used vary less dramatically. Most tools use lexical,

network, and geospatial analyses or combinations. The proliferation of social media platforms has increased the importance of these methods in intelligence gathering. The transition to Web 3.0 increases the efficiency of these methods with the effect of machine learning and natural language processing. Although the abundance of commercially available open-source analytical tools makes it difficult to assess their capabilities, the methods' components provide benchmarks for this evaluation.

6.2. Lexical Analysis

In the age of social media, open-source tools stand out for their ability to simultaneously bring together significant texts from various languages and cultures. Lexical analysis can show the most searched terms at the most basic level. In contrast, at a more advanced level, it can parse the meaning behind the language and extract demographic information. Advanced lexical analytical methods often require having a comprehensive body of text for reference. While built-in stems are available for some languages, many languages do not, which can limit the use of lexical analytic tools. Machine learning helps address language gaps in lexical analysis and continues to improve over time. These methods have become even more critical regarding intelligence gathering with the proliferation of social media platforms. The transition to Web 3.0 increases the efficiency of these methods, making them more effective for intelligence purposes.

6.3. Keyness Analysis

Keyness refers to the frequency with which a word appears in a sentence or post. Analyzing keyness can clearly depict a speaker

or writer through their choice of words. For example, certain words are more commonly used in English sentences written by native speakers than by non-native speakers.

6.4. Frequency Profiling

Keyness is also used in frequency profiling, which involves distinguishing one body of text from another based on specific keywords or comparing a sample body to a larger dataset. One application of frequency profiling is to attribute material to a particular source, given a sufficient number of verified citations. It can also identify different "phases" in a person's writing or speech. For instance, researchers at Arizona State University utilized frequency profiling to detect early signs of Alzheimer's disease in an individual before a formal diagnosis was made.

6.5. Clusters

A cluster is a sequence of two or more words that may not necessarily form grammatical or meaningful units but can still be incorporated into keyword analysis.

6.6. Collocation

String syntax refers to the likelihood that two words identified in a keychain analysis frequently appear together, typically within five words of the target word (or "node"). This concept enhances search functionality and aids in identifying key themes within a text. It is crucial because it reveals how individuals associate different concepts. For instance, in their study on the discourse surrounding refugees in the UK, Baker and colleagues found that the terms "*migrant*," "*refugee*," and "*asylum seeker*" consistently shared numerous synonyms, suggesting that the UK

press often connects these concepts in the public's mind, whether intentionally or unintentionally.

6.7. Sentiment Analysis

Sentiment analysis identifies terms or entities representing "*a general majority opinion not shared by another group*"; for instance, a political figure may be perceived as divisive. Its primary purpose is to categorize online opinions as positive, negative, or neutral. This technique can be applied to a range of topics, including political discourse in the U.S. or support for groups like ISIS in the Middle East. However, some researchers warn that over-relying on sentiment analysis may exaggerate social media's capacity to reflect broader societal perspectives, as it only captures the views of a specific, online, engaged population segment.

6.8. Stance Analysis

Sentiment analysis reveals how language can differentiate viewpoints between individuals or groups, while posture analysis examines language choices to reflect an individual's core values or attitudes toward a specific concept. For example, Marcellino uses posture analysis to demonstrate that the U.S. Marine Corps communicates in a distinct, internally consistent manner, using "future-oriented, inclusive, and relatively precise language."

6.9. Natural Language Processing

In the past, researchers and intelligence analysts relied on human translators and interpreters to process large volumes of foreign-language texts. However, advancements in text analysis and natural language processing have significantly reduced this burden, providing various tools for faster translation and processing of

foreign materials. Resources like Google Translate are free and open-source, allowing users to improve machine-generated translations and refine the algorithms over time. Cohen and colleagues note that while automated translation services "are not as accurate as human experts translating website content," their main advantage lies in the speed with which they can process vast amounts of data. This speed is precious for intelligence analysts who must quickly evaluate the potential threat of an individual's post on an extremist website.

6.10. Machine Learning

Machine learning enhances the efficiency of all lexical analysis processes and tasks mentioned above, such as calculating key terms, detecting phrases, translating materials, and performing sentiment analysis. It enables software programs to make decisions independently of humans after their decision-making processes have been thoroughly modeled. However, machine learning requires experts in machine learning and computational linguistics to design the initial parameters and adequately "train" the system to recognize linguistically significant patterns in written text.

6.11. Applying Lexical Analysis Tools

Using the tools outlined above, lexical analysis can provide detailed insights into authors and their broader context, including the communities they identify with, the audiences they intend to reach, and potential shifts in ideology or perspectives over time. Increasingly, lexical analysis relies on collecting corpora from the Internet, where individuals share ideas, post, tweet, and express their opinions in numerous ways daily. As tools like natural language

processing and machine learning for sentiment and posture analysis continue to evolve, this method and its application in intelligence gathering are likely to expand.

6.12. Social Network Analysis

Decades before the advent of the latest generation of web-based applications, social network analysis sought to explain relationships between individuals as a series of changes that could be mapped and plotted to explain the past and predict future interactions. The basic principles of social network analysis are:

- Actors are not seen as autonomous but interdependent.
- Relational ties between actors are channels for the transfer or "flow" of resources (tangible or intangible).
- Network models view the built environment as providing opportunities or constraints for individual action.
- Network models conceptualize structure (social, economic, political, etc.) as permanent patterns of relationships between actors.

7. TOOLS USED IN OSINT ANALYSIS

Auxiliary software used to perform OSINT analysis can shorten the analysis processes. Since the scattered information on the Internet can be in many different platforms and formats, these tools are designed to provide services on specific subjects. Access to all data sources with a single tool has not yet been achieved. In this context, some well-known auxiliary tools and their usage areas are given in **Table 1** (Browne et al., 2024).

Table 1. *Some Tools Used for OSINT Analysis and Their Uses (Browne et al., 2024)*

Tool Name	**Usage Area**
Greyhat Warefare	Online storage search
TheHarvester	Online reconnaissance
Spiderfoot	Information aggregation, multiple sources
Maltego	Information aggregation, multiple sources
Sublis3tr	Subdomain names
Spyse	Online reconnaissance
Intelligence X	Online reconnaissance
Recon-NG	Online reconnaissance
Searchcode	Source code search engine
Whois	DNS lookup
BuiltWith	Website technology profiler
Tweepy API	Twitter scraping
Grepp	Source code search engine
Shodan	Devices search engine
What CMS	Website technology profiler
PwnDB	Compromised email search
OnionScan	Dark web investigation
WalletExplorer	Bitcoin wallet search
Block List	IP address blacklisting
Exploitdb	Exploit database
DataSploit	Information aggregation, multiple sources
Low Hanging Fruit	Online reconnaissance
Search is Back	Facebook Search

8. OSINT USAGE AREAS

When the national literature was examined, OSINT uses were found in the following areas from the studies on open-source intelligence:

8.1. Social Media Reviews

- Arslan and Yanık (2015): It has been stated that social media has changed communication habits and is a valuable resource for OSINT.
- Ekşim and Civelek (2019): It has been emphasized that social media is used to detect zero-day attacks and prevent cyber attacks.
- Tiryaki and Özdal (2020): The potential benefits of social media in various areas were analyzed.
- Sezgin and Boyacı (2023): It is recommended to structure the data obtained from social media and cyber security sites.
- Bural (2024): It has been stated that posts made by soldiers on social media may threaten the security of military operations.

8.2. Cyber Security

- Ekşim and Civelek (2019): A semi-automated OSINT-based intrusion prevention model was proposed using intelligence obtained from social media.
- Eksim and Kara (2019): OSINT is an essential tool in the fight against cybercrime.
- Sezgin and Boyacı (2023): It has been suggested to obtain cyber security intelligence by transforming raw data into structured data.

8.3. Counter-Terrorism and Military Intelligence

- Çıtak (2021): The role and advantages of OSINT in the fight against terrorism are discussed.
- Erol (2022): It has been argued that AKIS is not used enough in military intelligence and that appropriate processes are lacking.
- Çağlak (2023): The contributions of the Directorate of Printing and Intelligence in the period of the National Struggle were examined.

8.4. General Intelligence Methods

- Dağdeviren and Kedikli (2023): Intelligence methods used by states were analyzed comparatively.
- Ökten (2023): The role of open sources in intelligence studies and essential topics were discussed.
- Taban and Aydilek (2023): The transformation of intelligence analysis in the digital age and the effects of new analysis methods are examined.

Another literature review reported academic studies on the following subject, and several fields where OSINT can be applied with artificial intelligence and machine learning methods were found (Browne et al., 2024).

- Security Operations (68 research)
- Law Enforcement (57 research)
- Intelligence Services (56 research)
- Cyber Threat Intelligence (48 research)
- General Topics (34 research)
- Government Departments (32 research)
- Non-Governmental Organizations (18 studies)
- Cyber Risk Management (8 studies)
- Public Health (6 studies)

- Defense (6 research)
- Emergency Services (6 investigations)
- Penetration Testing (6 research)
- Cyber Incident Response (6 investigations)

9. ETHICAL AND LEGAL ISSUES

The accessibility of OSINT to inexperienced or malicious individuals can lead to unethical practices, such as the online sharing of private information or misidentifying individuals involved in illegal activities. These actions could have profound implications for public safety and national security. Despite the General Data Protection Regulation (GDPR), there has been little substantial impact on OSINT collection practices, with most changes arising from social media platforms updating their privacy settings. The increasing reliance on AI to automate OSINT collection and analysis is driving the emergence of a third generation of OSINT. Expanding new data sources enables the discovery of previously hidden patterns, further blurring the boundaries of intelligence applications. Additionally, the potential integration of OSINT with augmented reality presents new challenges. These advancements raise concerns about potential ethical violations within the OSINT community (Ghioni et al., 2024).

There is no doubt that online terrorist propaganda research has not paid enough attention to ethics in recent years. OSINT-based investigative projects focused on terrorist information ecosystems must adopt the same highest technical standards applied in cybercrime investigations for years (Lakomy, 2024).

A study showed that open-source newsrooms and organizations operating in the Netherlands do not apply privacy rules or frameworks to their journalists. The author reports that this is a problem and that similar research should be disseminated to other countries and examined (van der Woude et al., 2024).

GDPR rules are applied abroad, and the Personal Data Protection Law No. 6698 is applied in our country. When the definition of open data is examined, it is emphasized that the information disclosed to the public by the person is no longer personal data. For this reason, while it is a crime to take a person's picture without permission under Law No. 6698, the fact that this person publishes the picture he took with his hand on the social media platform and that someone else takes this picture may not be contrary to the personal data protection law.

10. THE FUTURE OF OSINT AND EMERGING TECHNOLOGIES

Today, artificial intelligence has come into play to find and classify the desired data from the big data created on the Internet. In order to collect open-source intelligence, artificial intelligence can scan vast amounts of data produced worldwide and work like an intelligence element. For intelligence services, artificial intelligence can provide significant speed and accuracy in collection activities from open sources (Bural, 2024).

The advent of the internet, big data, and generative artificial intelligence has significantly transformed the field of geological sciences, offering unparalleled opportunities for the collection, analysis, dissemination, and production of geographic information.

In the current digital era, concerns about the silent leakage of personal information are escalating, with geographic privacy emerging as a critical issue. One often overlooked aspect of geo-privacy leakage is the geographic information embedded in photos. While this data may have been challenging to extract, advancements in technology now make it possible to deduce sensitive location details from seemingly harmless images. For instance, consider a situation on social media where an individual posts a photo taken at a baseball stadium. From this image, the specific stadium can be identified, and, in some cases, even the exact address can be pinpointed, compromising geographic privacy with just a single photo (Yang et al., 2024).

The increasing use of artificial intelligence to automate much of the collection and analysis process, now called second-generation OSINT, suggests the emergence of a third generation that will rely more on computer algorithms and automated reasoning rather than analyst oversight. Unlike other intelligence disciplines, OSINT benefits from developments in the digital world, which are expanding as new technologies emerge. As new data sources become more accessible, previously hidden patterns can be uncovered, further blurring the boundaries of intelligence applications. For instance, the potential integration of OSINT with augmented reality is possible today (Ghioni et al., 2024).

The multiplicity and diversity of data produced over the Internet are increasing daily. Trying to extract information from this seemingly gigantic information dump is like looking for a needle in a haystack. Thanks to the developing technologies, new technologies

will increase storage capacities and calculation speeds, but this cycle seems to continue similarly.

11. CONCLUSION AND RECOMMENDATIONS

11.1. Conclusion

This study comprehensively assessed the growing role and importance of Open-Source Intelligence (OSINT) in modern security and intelligence activities. While traditional intelligence methods are based on confidential information collection and analysis processes, OSINT stands out as a method that provides strategic decision support by analyzing information obtained from public sources (such as the internet, social media, official documents, and media content). Offering access to a wide range of data without needing confidential information, OSINT offers significant differences compared to traditional intelligence with the advantages of providing low-cost and legal access.

The most effective uses of OSINT include cybersecurity, counterterrorism, border security, and crisis management. For example, publicly available data from social media and other digital platforms is a strategic resource for identifying potential threats, ensuring rapid information flow in crises, and analyzing trends such as radicalization in certain regions. Especially in cyber security, a proactive approach is developed with OSINT tools against rapidly evolving threats such as zero-day attacks; Threats to critical infrastructures are monitored with social media analysis.

The study's findings reveal that integrating OSINT with technologies such as artificial intelligence, natural language processing, and data mining in data collection and analysis processes

increases efficiency. Thanks to these technologies, obtaining fast and accurate information from publicly available data has become possible. At the same time, the capacity for timely intervention with real-time data analysis has also improved. However, the widespread use of OSINT brings some ethical and legal challenges. It is essential to consider the sensitivities regarding privacy violations, the privacy of individuals, and information security during public data collection to ensure the responsible use of OSINT.

As a result, OSINT has become an essential component of modern security policies as a complementary alternative to traditional intelligence. With continued digitization and the ever-increasing data, OSINT is expected to be applied more broadly. In this context, OSINT is considered an effective security tool balanced with ethical and legal regulations while providing a strategic advantage to decision-makers against rapidly changing security threats.

11.2. Recommendations

In the light of the information obtained within the scope of our study, the following suggestions can be made:

1. **Strengthening Legal and Ethical Regulations:**
   OSINT's collection of information from publicly available data requires a careful approach to privacy and ethics. For this reason, it is essential to develop legal frameworks that will protect individuals' privacy rights and carry out OSINT activities by ethical rules. In particular, it is recommended that the legal regulations regarding data collection processes from social media and digital platforms should be updated at the international level.

2. **Technological Investments and Artificial Intelligence Integration:**
   The rapid increase in data volume in OSINT processes can challenge traditional analysis methods. In this context, integrating artificial intelligence, machine learning, and natural language processing technologies into OSINT will enable faster and more accurate analysis. Increasing technological investments to detect and prevent risks is essential, especially in real-time data flow. In this context, blockchain-based data storage techniques have the potential to offer better solutions to the questions of who owns the data and who accesses this data.

3. **Increasing the Use of OSINT in Cyber Security and Crisis Management:**
   OSINT can potentially deliver critical information in cybersecurity and crisis management emergencies. Accordingly, it is recommended that government agencies and the private sector integrate OSINT into their cybersecurity strategies to increase their capacity to identify potential threats in advance and react quickly.

4. **Training and Capacity Building:**
   The use of OSINT is a process that requires particular expertise. For this reason, it is necessary to organize training on OSINT in security institutions and intelligence units to develop expertise and raise awareness. These trainings should cover essential topics such as OSINT analysis methods, tools used, and data ethics rules.

5. **International Cooperation and Information Sharing:**
   OSINT is an effective tool in the fight against global threats. Therefore, establishing OSINT-based information-sharing mechanisms between countries will facilitate coordinated action against international security threats. International cooperation will also help establish common ground on the ethical use and privacy standards of OSINT.

6. **Increasing the Diversity of Tools and Resources:**
   The variety of tools used for OSINT analyses can increase the scope and accuracy of analyses. It is recommended that OSINT tools be developed to collect information from different data sources and adapt these tools to current threats. Thus, analyses with OSINT tools will become more inclusive and efficient.

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