Funded by the European Union's
Horizon Europe programme under
the grant agreement No 101096487

D2.1 Integrated Sustainability Assessment Framework

WP2 Business Cases, Environmental Footprint, Sustainability, Social Impact

Disclaimer

The content of this deliverable reflects only the authors' view. The European Commission is not responsible for any use that may be made of the information it contains.

Document Information

Grant Agreement / Proposal ID	101096487
Project Title	AUTONOMOUS FLYING SHIPS FOR INTER-ISLAND AND INLAND WATERS TRANSPORT
Project Acronym	AIRSHIP
Project Coordinator	Universidad Politécnica de Madrid
Project starting date (duration)	1st January 2023 (48 months)
Related Work Package	WP2
Related Task(s)	T2.1
Lead Organisation	TalTech – Tallinn University of Technology
Contributing Partner(s)	LRPC – La Palma Research Centre
Due Date	31 December 2023
Submission Date	18 December 2023
Dissemination level	Confidential

Funded by the
European Union

Revision History

Revision	Revision Date	Name	Position
1	01/09/2023	Kristin Kerem	Research Assistant
2	20/11/2023	Riina Otsason	Junior-Researcher
3	01/12/2023	Helena Robert Campos	Early-Stage Researcher
4	04/12/2023	Riina Otsason	Junior-Researcher

TABLE OF CONTENTS

Funded by the
European Union

List of Tables

List of Figures

Funded by the
European Union

Abbreviations and Acronyms

Acronym	Description
D	Deliverable
ECOSOC	United Nations Economic and Social Council
EU	European Union
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
RCEP	Royal Commission on Environmental Pollution, United Kingdom
SDG	Sustainable Development Goals
SNM	Strategic Niche Management
TBL	Triple Bottom Line
WP	Work Package
UN	United Nations

Table 1. Abbreviation and Acronyms

EXECUTIVE SUMMARY

The aim of the following deliverable is to develop an integrated sustainability assessment framework that considers environmental, economic and social dimensions of the AIRSHIP project.

This deliverable introduces various ways of assessing maritime projects and outlines an integrated sustainability assessment framework for AIRHSIP project. The first two chapters of the deliverable provide an overview of a thorough literature review of the different definitions of the term sustainability and of various sustainability frameworks. The third chapter assesses AIRSHIP by analysing the factors that affect the project. And finally, based on these analyses, the deliverable proposes a framework to assess the sustainability of the AIRSHIP project combining the unique features of the AIRSHIP WIG vehicle – ability to work at and above sea.

The developed framework considers the performance of the technology in terms of the business-case, environment, socio-economic, policy and overall sustainability aspects. Such a framework is the basis for the work of the second Work Package of the AIRSHIP project. This integrated sustainability framework outlines the parameters to be considered throughout the execution of the project, by degree of importance and dimension (e.g., environmental, economic, social etc.), which, in practice, implies the necessary interaction between WP2 and all other project WPs. As the outcome of the first-year project work, it is expected that the framework proposed in this deliverable will be revised as the project develops.

The deliverable was compiled by the partners from TalTech, Estonian Maritime Academy research group led by prof. Ulla Pirita Tapaninen, members Riina Otsason, Seçil Gülmez and Kristin Kerem and LRPCS La Palma Research Centre, junior researcher Ariadna Ortega Rodriguez and Helena Robert I Campos.

Funded by the
European Union

1 Historical Overview of Sustainability

1.1 Early History of Sustainability

Sustainability seems to be a rather new term. Many authors refer to the 1987 Brundtland report (Brundtland, 1987) as the start of discussions about sustainable development by giving the first interpretation of the meaning of the term: "sustainable development is a development that meets the need of the present without compromising the ability of future generations to meet their own needs." (ibid, 43). Nevertheless, it does not give a meaning to *sustainability* as a term.

However, the concept of sustainability precedes the cited report, and it can be followed through the change of the meaning of the word *sustain*. According to the *Merriam Webster's Dictionary* (2012), *sustain* means "to keep up, prolong." Thus, sustainability in its simplest form means to keep something going (Farley 2014). Historically (Farley, 2014) and according to the etymological dictionary (Online Etymological Dictionary, 2023), the first recorded meaning of the word is from the late 13th century, meaning at the time "to provide necessities of life to". It has kept most of its original meaning until today, though it has gone through several modifications - from "give support to, support physically" during 14th century, to "keep up or maintain uniformly" in 18th century. Its origin goes deeper, and, from the Proto-Indo-European root, it can relate to the meaning of "stretch". From the 1610s, the form "sustainable" has been used as an adjective, describing something as "bearable". The concept has developed further, meaning by 1965 "capable of being continued at a certain level". This corresponds to the descriptions of Trapaga-Monchet et al. (2023) in their understanding of human beings' minimal impact on the ecological systems up until the 18th century. There were considerations to sustainability also in Early Modern times, in line with the argument that colonisation was one of the triggers that led to the to introduction of the ideas of conservation as the limit of recreation into the minds of the society at the time (Farley, 2014). Within this context, Thomas Malthus (1992) put forward his ideas of "natural limitation" of the population in 1798, and, a century later, in 1898, Alfred Russel Wallace (1890) was one of the first scientists to highlight that environmental damage done by reckless extraction would negatively impact the future generations.

Term *sustainability* as a noun is first found in written from in 1907, in reference to legal objection and has continued to acquire meanings in many different subjects, for example, in economics and agriculture as well as in ecology, among others, becoming a widespread term by 1972. Since then, several fields that have defined it according to their internal rules – in Economics, sustainability refers to the ability to maintain or support a process continuously over time (Klaassen, 1991). In Social Sciences, it refers to the ability of people to co-exist on Earth over longer period. UNESCO has defined sustainability as the long-term goal of sustainable development, including many processes and pathways through which such sustainability can be reached.

Nevertheless, the most common definition of *sustainability* is nowadays still that from Brundtland Report. It has, however, been the focus of certain criticism. Asheim (1994) regards sustainable development from the intergenerational justice approach, and thus finds Brundtland Report to be too limiting. In his view both, intragenerational justice (within one generation) as well as intergenerational justice (from one generation to other) to be necessary to achieve sustainability. He finds sustainability to be possibly achieved only with the altruism of the future generations as the generations today do not have the means and knowledge that would enable them to keep the same quality of life while saving the resources for the future generations. By comparing human made capital and natural capital, he comes to the conclusions that sustainability can be achieved only by intergenerational distribution and not via aggregated capital good. Furthermore, Asheim defines ethical criteria for sustainable development - to achieve sustainability, present generation must sustain from the ideal of everything expanding and benefitting from every endeavour in favour of leaving it to be acquired by future

Funded by the
European Union

generations. It would mean lower quality of life for current generations in favour of future generations having something to benefit from. In summary, he is an advocate of limited growth.

Hartwick posed a rule in 1977 regarding that sustainable development could be characterized as a development where the quality of life is held a constant (Hartwick, 1967). It assumes that population and stationary technology remain the same. According to Hartwick, if the quality of life remains constant, it corresponds to the increasing total value of the capital stocks while the interest rate is decreasing. This was also basis of the analysis of Asheim and led to the conclusion of limited growth being an option and necessity for sustainability. However, the model has been updated by Dasgupta-Heal-Solow to show its actions with one capital good and one non-renewable resource might have zero effect on sustainability. It is discussed in length by Martinet (2004), including complex mathematical analysis concluding that the Hartwick rule and its modifications do not indicate sustainability but merely the efficient use of the exhaustible resources. Martinet defines in his work the *sustainable consumption indicator* – „If sustainability requires the current consumption to be attainable by all future generations, this indicator provides a good information. If it does not decrease, the current decisions are "sustainable". Such an indicator can consider changes in the production function and discovery of new resource stock. Nevertheless, the sustainability concern can not be reduced to such a consumption indicator. Further research needs to be done. In particular, we aim for a generalization of this approach to any consumption path (not only constant ones) and for the study of a decentralized economic model.

Furthermore, Chofreh et al (2017), find that the definition is vague and does not include three main dimensions – environmental, economic, and social, together often named as the triple bottom line (TBL). According to their ideas, it would be the best if the long-term profitability of any company is achieved through balancing profits with social and environmental objectives. Hence according to Chofreh, any framework created should also tackle the need of information of broad range of users, including the four main elements – how to apply sustainability to the organizations, set objectives of projects, qualitative measurable features to decide on the usefulness of the information contained and finally any framework should define the elements of the systems.

1.2 International Framework on Sustainability

While the Brundtland Report (1987) is generally regarded as the first driver of sustainability measures on the international scene, the first ever global summit on sustainability was the 'UN Conference on the Human Environment', held in 1972 in Stockholm (United Nations, 1972). As suggested by Sweden to the United Nations Economic and Social Council (ECOSOC) in 1968, It was the first occasion when the links between social issues, environment and economy were discussed together by 113 countries of the world. Result of the conference was the creation of the UN Environment Program as the problems of the environment were already noticed and attention was brought into which direction the development will be turned and which qualities and values should be valued in future. From the maritime point of view, the important result of this conference is the Annex 3 of the conference proceedings that state the general principles for assessment and control of maritime pollution. (UN, 1972, lk 73)

In 1992, at the UN Conference on Environment and Development, also known as the Rio Conference or the Earth Summit, the notion of *sustainable development* was further discussed. As a result, the Agenda 21 was adopted as a non-binding action plan, setting out guidelines to achieve sustainable development by 2000, hence for the 12st century. During the decades following this action plan, further developments have been made pursuing the same goal, including the eight Millennium Development Goals (UN, Millenium Declaration, 2000), succeeded by the "The Future We Want" resolution adopted by UN General Assembly in 2012 (UN, 2012). The Future We Want describes in detail different aspects of life and sets targets in its 283 points. It is rather detailed and long document, hence, to make it easier for public to understand and accept, the the seventeen Sustainable Development Goals (UN, 2016) were described with measures to be monitored. The target for these goals it to

Funded by the
European Union

be achieved by 2030. However, these goals were not legally binding and by today, the number of goals has reached 17. Every year the report of current state of achieving the goals is published by UN (UN, 2023).

On 25 September 2015, the UN General Assembly adopted the 2030 Agenda for Sustainable Development, which represents an urgent call for action involving all UN Member States, in a global partnership (UNOSD, 2020). Constituted by 17 SDGs, broken down into 169 targets for the period 2015-2030, it represents a common roadmap for countries to adopt measures at different levels to make the transition to sustainable development (United Nations, 2015). In the last decades, the international community has recognised the impact of the current growing trend, that human action in the era of the Anthropocene has triggered drastic changes in the conditions on the planet and its inhabitants at all scales, which in turn have contributed to the deterioration of the environment and human wellbeing (UNWOMEN, 2014). There is, thus, an urgent need to develop synergies and manage trade-offs between the different SDGs, which can no longer be tackled as isolated items (OECD, 2020, p. 29). It is precisely for this reason that during current project, a connection between the SDG and project results will be analysed throughout the subsequent deliverables following this work. According to the UNDP (2012), the achievement of the targets set by the SDGs passes through a structural change of the current development model, which has since decades been focused on production and consumption at the expense of natural resources as well as the working class -especially in less developed areas (p. 32). Such development patterns rely on and reproduce gender inequalities, exploiting women's labour and unpaid care work (UNWOMEN, 2014). This profound structural transformation requires a joint effort by the international community, involving all its actors in the decision-making processes at different scales. This makes the UN 2030 Agenda and its SDGs the biggest challenge of the current and upcoming decade, and the clearest example of the complexity of MLG in an interconnected world (UNDP, 2012, p. 32).

Wang et al (2020) have concluded in their article that the shipping industry and the maritime industry in total are not very good at making the public know of how they impact the world and how much work has actually been done within the industry using the core competences to let the public know how sustainable the industry already is today and more publishing in this direction is necessary to overcome the myths and the stereotypes associated with ships and waterways.

1.2.1.1 Sustainable Development Goals Connected to AIRSHIP

As seen above, *sustainability* as an idea has been developed since humans started to use the natural resources. Nevertheless, with Agenda 21 (UN, 1992) and Agenda 2030 (UN, 2015), the set development targets of sustainability have created the new wave of possibilities to use the advanced technologies in the best possible way in terms of achieving sustainability for the future generations. Airship project is being designed with these goals in mind, hoping to solve at the same time not only the transport issues between two locations, but also the adjacent problems of workforce related issues. The next chapters will lay out the details of how the targets set by the SDGs can be met and measured within the project and later when the airship is deployed in everyday life.

Airship project in its entirety can have impact on several of the SDGs – in total, project will have affect on 9 SDGs out of 17. The biggest impact is on the SDGS 11 (sustainable cities and communities), 14 (Life below water) and 15 (Life on land). The actual SDGs and the way the project have effect on them can be seen in following table:

Goal	Impact	Affected targets
2 – Zero hunger	Enabling transport to areas, that are difficult to reach, and paying its main attention on providing automated solution for the cargo transport, AIRSHIP is also assisting in	2.1

Funded by the
European Union

	fighting the hunger in the world through being suitable for fast deliveries of short shelf-life goods.	
3 – Good health and well-being	Sustaining traditional habitats by enabling another fast mean of transport to areas that are difficult to reach. This helps to provide with medical equipment and medicines in a fast and effective way.	3.4,3.6, 3.9
7 – Affordable and clean energy	The Airship project aims to build a vehicle that will not use fossil fuels to operate.	7.1, 7.2, 7.3, 7a, 7b
8 – Decent work and economic growth	By enabling transport to difficult areas, it helps to create workplaces related to shipping as well as in transport sector. Autonomic vessels have the benefit of operators living and working on dry land, hence improved work conditions compared to two weeks at sea without seeing ones' family. Adding transporting capacity help to increase also economic growth through offering faster and safe transportation option.	8.2, 8.5, 8.6
9 – Industry, innovation, and infrastructure	Transport as such is part of infrastructure that enables industries to have the much-needed supplies as well as enables fast deliveries to remote customers. Airship as such is innovation in transport in all aspects.	9.1, 9.4
11 – Sustainable cities and communities	Being sustainable on all possible ways, Airship helps the cities to be sustainable – having low pollution levels means possibility to have connections from city centres to city centres, hence enhancing communication and transport between communities.	11.2, 11.a
12 – Responsible consumption and production	Through usage of optimised production lines and careful design of the airship enable minimum	12.2, 12.4, 12.6, 12.c

Funded by the
European Union

	consumption of natural resources during production phase as well as later while in service.	
14 – Life below water	As airship does have minimal impact on the waters, creating minimal waves and having no contact with the water during its flight time, it fulfils the criteria of having minimal impact on the lift below waters.	14.1, 14.2, 14.7
15 – Life on land	The airship will have some effect on the life on land. Due to its speed, it may affect birds and it may have effect on the existing traffic on its route.	15.8

Table 2. SDGs relevant to the Airship project

AIRSHIP project has a good chance to use all the possible publicity channels to promote the SDGs influenced by this project and possibly later also by the airship itself and its use to the society.

2 Literature Review of Sustainability Frameworks

Over the years, many frameworks regarding different elements that lead to sustainability have been created. Chofreh et al (2017) have concluded in their works a thorough overview of the sustainability frameworks on implementation of sustainability created before 2017. In the following list there will be analysed articles that have been published in 2017-2022 about sustainability in connection to the transport or maritime environment and services offered in connection to maritime activities. The articles have been selected by using the following keywords and the time limitation of 2017-2022 from the databases of Scopus and Google Scholar. A few articles of 2023 have been added by authors' discretion as these are showing the development trends.

The articles were chosen from the above-mentioned databases based on following keywords: „sustainability", „framework" „transport" „maritime" in various combinations. Scopus database provided in total 1067 articles of the given period including the keywords *sustainability, framework, and transport,* most of them on field of social sciences (542), environmental science (489), engineering (403) and energy (322). Other fields of research followed with lower numbers. Google Scholar provided result of about 22100 articles, so the search there was retried by changing the search entry to *„sustainability framework" and transport* which retrieved in total 627 articles. Search for *„sustainability framework" and maritime"* resulted in 69 articles in Google Scholar and 298 in Scopus database.

2.1 Existing Frameworks

Chofreh et al (2017) have concluded in their works a thorough overview of the sustainability frameworks created before 2017. Though none of these have any specific maritime background, the method of conceptual research draws the attention as including many aspects like the current framework as can be seen on the following figure (Figure 1):

Funded by the
European Union

Author (year)	Research focus	Dimension	Method
		7. Outlook 8. Basis of presentation	
Hahn *et al.* (2015)	conceptual research corporate sustainability implementation	1. Analyze 2. Design 3. Implement 4. Monitor and control	conceptual research
Laurenti *et al.* (2016)	global sustainability implementation	1. Plan: defining, forecasting, organizing 2. Do: demanding, executing 3. Check: controlling, coordinating 4. Act: standardizing, correcting	conceptual research
Panagiotakopoulos *et al.* (2016)	sustainability management	1. Operations 2. Management 3. Environment	conceptual research
Gallotta *et al.* (2016)	corporate sustainability implementation	1. Sustainability dimensions 2. Systemic 3. Organizational 4. Individual	conceptual research

Table 1. Review of research in framework for sustainability implementation

Figure 1 Summary of sustainability frameworks by conceptual research and their dimensions. Chofreh et al (2017)

Earlier studies have been mostly surveys or case studies, and BSI's standard on sustainably managing events is one of the first that relies on conceptual research (British Standards Institution, 2009). However, there are numerous methodologies employed within sustainability implementation frameworks, including conceptual research, survey, case study, peer review, or combinations of the above, as can be seen on Figure 2 Literature and applied methods according to Chofreh et al (2017, 184). Morse and Richards (2012) stated that the choice of methodology depends on the stage of the research and the nature of the problem to be addressed. No method can be considered superior to the others, and each has its own rationale and limitations. For instance, a case study methodology is undertaken to answer certain questions that cannot be answered through empirical survey. It is carried out to assess the degree of some phenomenon or to collect empirical evidence of this phenomenon (Yin, 2014).

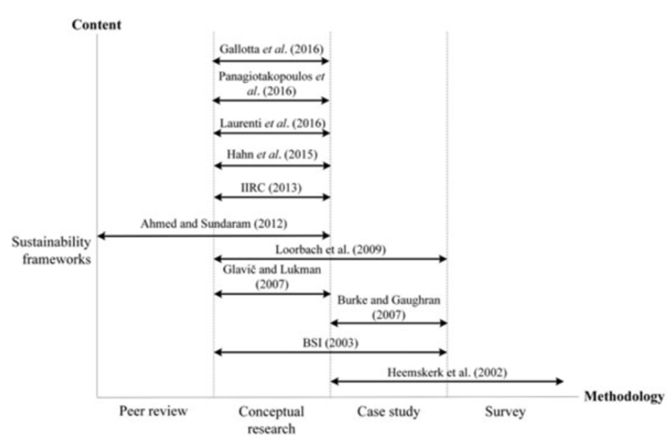

Figure 2 Literature and applied methods according to Chofreh et al (2017, 184)

Funded by the
European Union

2.2 Industrial Ecological Framework

Hoffman (2003) describes in his article a framework that puts together the industrial side of ecological problems with social factors and looks to find solution in the combination of these. According to him, the systems so far have avoided adding the social systems analysis to the industrial ecology and looked at the environmental problems purely from the technical viewpoint as it explains only the „what“, but not the „how“ when talking of possible solutions to the pollution problems. However, he sees it is necessary to retain the focus on the industrial organizations and on the systemic aspects of the organizational environment and avoid going into details and analyse on the level of individual. According to Hofmann, the technical environments modify the behaviour of the organization through physical, product and resource constraints while social environments pose restrictions on the organizational environment via protocols, processes, and procedural arrangements. There are companies, where the technical limitations overweigh the social ones and the opposite or where both are rather limiting – the latter is according to Hoffman valid for hospitals due to high demand of technical proficiency as well as strong demands from society in regard of their purpose, meaning and goals. From the perspective of maritime industry – it is rather limited in technical possibilities and has high goals and demands of the social requirements as there is many set rules and demands from international and governmental bodies, furthermore from the trade unions. Cavender-Bars et al (2015) have been analysing the ecology framework from the viewpoint of trade-offs of ecosystem management interventions and ecosystem services. According to them, it is important to combine stakeholders' perspectives with actual conditions and offer rather simple methods for comparison of different scenarios with their possible effect on the surrounding areas.

2.3 Strategic Niche Management

According to Hoogma (2002), technology must contribute to the creation and development of communities called niches where promising new technologies are to be tested via experiments. They base their argument on the assumption that whatever needs to be implemented, it will first be a social process and requires co-evolution or co-production from the community where it is created or tested. It is discussed through eight examples of such cases, including electric vehicles, on-demand transport, car sharing, bicycle pools, self-service public vehicles. Nowadays some of these technologies are already in a reality – electronic bicycles or carriers are available in many cities in Europe, car sharing is widely used, and on-demand transport is gaining popularity and has created a branch of research on its own (Safdar M, 2022), (Aden QA, 2022), (Auer S, 2022). The main aim of Strategic Niche Management framework (shortened SNM) is to induce long term changes, the effects of which might only be visible after decades.

SNM as a framework is intended for fixing the future, not offering immediate solutions. Its aim is to create new routines that could foresee the impact of our actions have and stimulate the learning and reflexivity for creating more sustainable technologies and mobility concepts. This framework includes detailed analysis of what makes technology successful and how to achieve it sustainably, both from the social and technological viewpoint. The reasons for new sustainable technologies to fail in their widespread usage are mainly the following (Hoogma, 2002):

- Technological factors – either technology is expensive or in short supply.
- Policy and regulatory framework – strict existing regulations prevent risk taking in testing and implementing the new technologies.
- Cultural and psychological factors – it is not easy to change the public's existing understandings of what are the means of transport and what it should look like or cost.
- Economic factors – new technologies tend to be expensive at start and that limits their usage to the lesser amount of consumers; only a few will accept higher cost for perhaps lesser performance in the implementation phase of new technology. Also, producers are not eager to risk connecting their brand to new, untested technologies.

Funded by the
European Union

- Production factors – investing into new technology means additional costs that might never be recovered if the new technology is unsuccessful.
- Environmental factors – new technologies bring with also new environmental challenges.

As the Airship project can be analysed based on the same factors, as these seem to be universal and not dependent on any specific technology, these factors are analysed within the PESTLE analysis (Political, Economical, Sociological, Technological, Legal and Environmental analysis) in corresponding chapter.

2.4 Decision Support Framework

In their article of examining the Greek coastal shipping network for suitable routes for the zero-emission electric ferries Karountzos et al. (year) propose a framework for analysing routes using exploratory spatial data analysis and local indicators of spatial associations to arrive to the possible new transhipment port hubs where the electrified ferries would have most effect and help to achieve sustainable transport solutions (Karountzos, 2023). The variables considered are the distance between the locations and possible suitability of the routes to the existing electrical vessels and the passenger and cargo demand on these routes. Second, they analyse the renewable energy sources capability of supporting such shipping operation as well as calculate the possible reduction of emissions achieved. While the route vs passenger and cargo analysis indicate clearly routes that would benefit from such solutions today, the renewable energy sources are scarce in these locations now and will require future investments (some of which are already in planning stage). As a result, the chosen method of analysis was the LISA model (model for determination of local indicators of spatial association) based on the geographic information system (GIS) data that has been analysed with exploratory spatial data analysis (ESDA)- Such combination has been proven to be a valuable tool for such analysis.

Nevertheless, it does not take into account that the needed zero emission fuel can be actually imported in one way or the other – this has been analysed in detail by Ha et al (Ha S, 2023) in their South Korea imported alternative fuel study, where they come to conclusion that the transport of renewable fuels needs to be also calculated into the total amount of emissions, though it is often left out.

2.5 Transdisciplinary Approach to Shipyards

When looking at the stake holders of any maritime project, one will need a shipyard to have a ship to start with. Hence looking into the sustainability of the shipyards as part of the stakeholder sustainability must be included in the framework. Vakili, Schönborn and Ölcer analyse in their article the possibilities of systematically approaching the shipyard and its possibilities to achieve sustainability (Vakili, 2023). They used Multi Criteria Decision Making (MCDM) methods as well as the Fuzzy Analytic Hierarchy Process and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution methods. The two latter have proven to be efficient in creating frameworks for the energy sector as they help to compare the various criteria according to the preferences of the stakeholders.

The results are presented as economic model, mainly in form of cost analysis. Their result is like the analysis of the findings of Karountzos (Karountzos, 2023). However, when starting to analyse the energy sector of the shipyards, they concluded that only transdisciplinary approach where professionals from several different fields work together to have a common understanding via common language is the preferred approach over multidisciplinary approach. According to them multidisciplinary approach would be insufficient – according to Vakili et al, it would mean too little co-operation between the professionals of different stakeholders and therefore also less common understanding and less synergy.

As part of their study, they divide the energy sector in the shipyards into three different systems – energy supply chain, energy economic system and energy ecosystem, latter being the widest term of all and including the other two as can be seen on Figure 3.

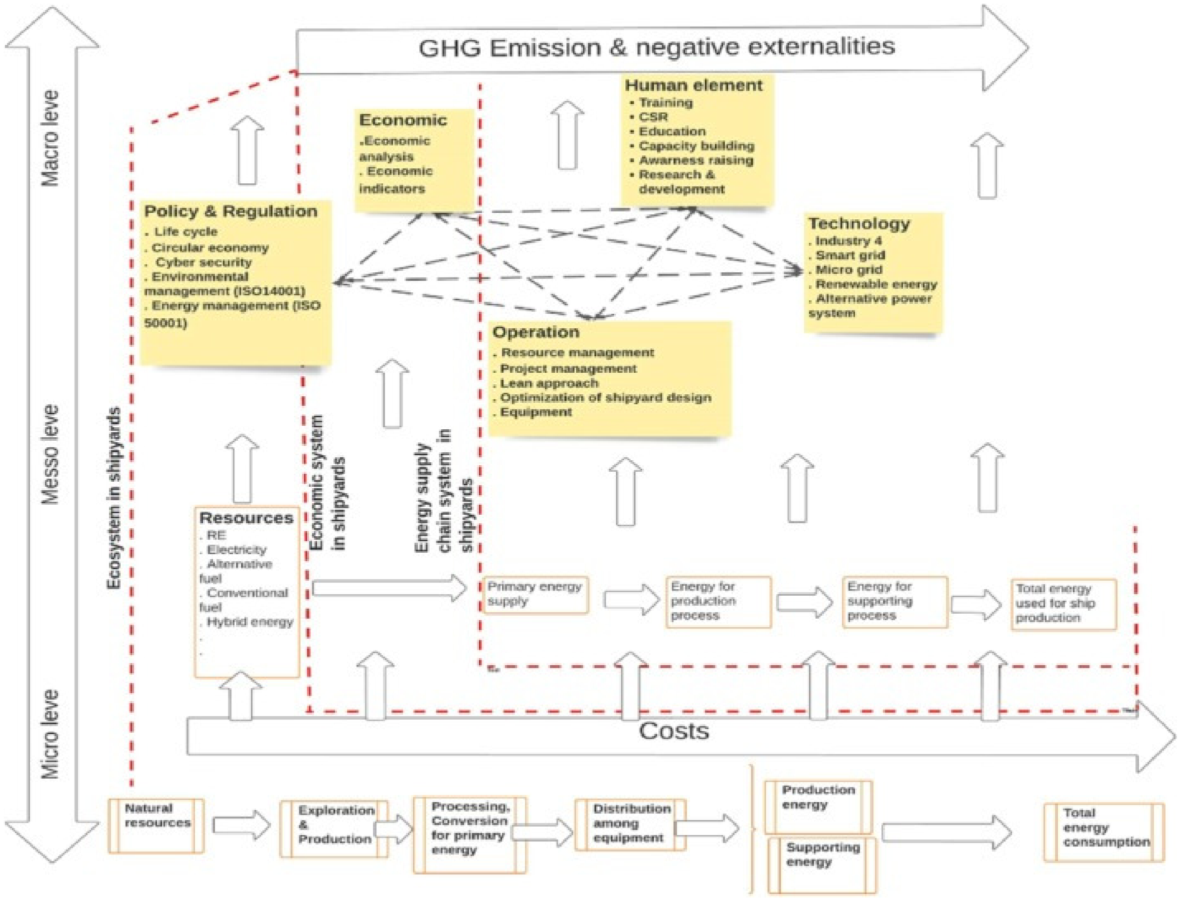

Figure 3 Energy sector in shipyards according to Vakili et al, 2023

Further they analyse the personnel, technical side of energy resources as well as operational side and look for optimization and emission reduction in all these subject areas. They suggest using Lean approach (Farshid, 2006), Just-in-Time (Vokurka, 2000), and Kaizen (Kato, 2011) methodologies as well as Corrective-Preventive actions and root cause analysis for better optimization. Finally, they find that the starting point should be in planning the layout of the shipyard in the way it best suits the above-mentioned optimization methodologies and enables to carry out each task with minimal effort. In the policy and regulation aspect, they investigate the life cycle of a shipyard, environmental management and energy management systems like ISO 14001 and ISO 50001 as well as circular economy possibilities and cyber security. To validate their framework, it has been applied to one of Italian shipyards.

2.6 Legal Frameworks

While looking at the sustainability, legal objectives of countries and economical areas also propose some challenges. Paramana et al (2023) have analysed the recent developments within the EU, especially within the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive, looking into ways to achieve coherence between both and existing legislation. (Paramana Th, 2023). Their main attention is in the Mediterranean, but their table of existing legal frameworks can easily be adopted by any EU country:

Table 3 Principal international conventions, agreements, organizations, and legislation to enhance a transboundary MSFD and MSPD implementation in the Mediterranean Sea.

FRAMEWORK	TYPE
The United Nations Convention on the Law of the Sea (UNCLOS)	International Convention
Convention on Biological Diversity (CBD)	International Convention
RAMSAR	International Convention
Barcelona Convention / UN Environment Programme – Mediterranean Action Plan	Regional Sea Convention (RSC)
ICZM Protocol	RSC Protocol
International Maritime Organization (IMO)	International Organisation
Food and Agriculture Organization of the United Nations (FAO)	International Organisation
International Commission for the Conservation of Atlantic Tunas (ICCAT)	International Organisation
International agreements under the General Fisheries Commission for the Mediterranean (GFCM)	International Agreement
Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and contiguous Atlantic area (ACCOBAMS)	International Agreement
Union for the Mediterranean	Intergovernmental institution
EUSAIR	Regional Strategy and Initiative
WEST MED	Regional Strategy and Initiative
Maritime Spatial Planning Directive (MSPD) 2014/96/EU	EU Directive
Marine Strategy Framework Directive (MSFD) 2008/56/EC	EU Directive
Water Framework Directive (WFD) 2000/60/EC	EU Directive
Habitats Directive (HD) on the conservation of natural habitats and of wild fauna and flora (92/43/EEC)	EU Directive
Birds Directive (BD) on the conservation of wild birds (2009/147/EC)	EU Directive

Funded by the
European Union

FRAMEWORK	TYPE
Strategic environmental assessment Directive (SEA) on the assessment of the effects of certain plans and programmes on the environment (2001/42/EC)	EU Directive
Environmental Impact Assessment Directive (EIA) on the assessment of the effects of certain public and private projects on the environment(2014/52/EU)	EU Directive
Common Fisheries Policy (CFP) and Council regulation 2371/2002 on the conservation and sustainable exploitation of fisheries resources	EU Policy

EU directive of marine spatial planning (EU, Directive 2014/89/EU, 2014), MSP in short, is one of the key documents that instructs all the members of the EU to plan their life around the sea and influencing the sea in sustainable ways while taking into account social, economical and environmental aspects. It expands the framework created with marine environmental policy directive, or the marine strategy framework directive MSFD for short (EU, Directive 2008/56/EC, 2008) As the later started the works on looking at the states of our waters and marine environment, MSP expands it looking into more aspects, especially regarding the planning of the costal areas and the load it puts on the waters.

As AIRSHIP is a wing-in-ground (WIG) vehicle, in addition to the frameworks given above, there are also co-operation between IMO and ICAO, defining the WIGs as half ships- half airplanes depending on their height of operation – if it is lower than 150meters, the WIG is considered a ship and operates according to the shipping regulations. If operation level is above 150 meters, it is considered also an airplane and needs to operate according to air standards. Hence the WIG that operates on both heights needs to correspond to both rules. This topic is to be researched separately, from technical as well as legal perspective. (IMO, Interim guidelines for wing-in-ground (WIG) craft, 2002).

2.7 Framework for Bioenergy System Assessment

While looking into the sustainability, use of biomass as source of energy, has been widely discussed. Elghali et al (2007) have been developing such framework using the multi-criteria decision analysis (MCDS) and decision conferencing for achieving the best results. Like others, they see sustainability with a multi criteria approach, mainly as balance between economic viability, environmental performance, and social acceptability. Their approach is close to the authors, by starting to identify the stakeholders, determining the driers, trade-offs between competing objectives, understanding the supply chain and determining the specifics of technology in terms of sustainability. They propose a workflow for the decision making, adapted from RCEP:

Funded by the
European Union

Based on the above schema, team has developed an 8-step procedure for using MCDA for analysis given in figure 4:

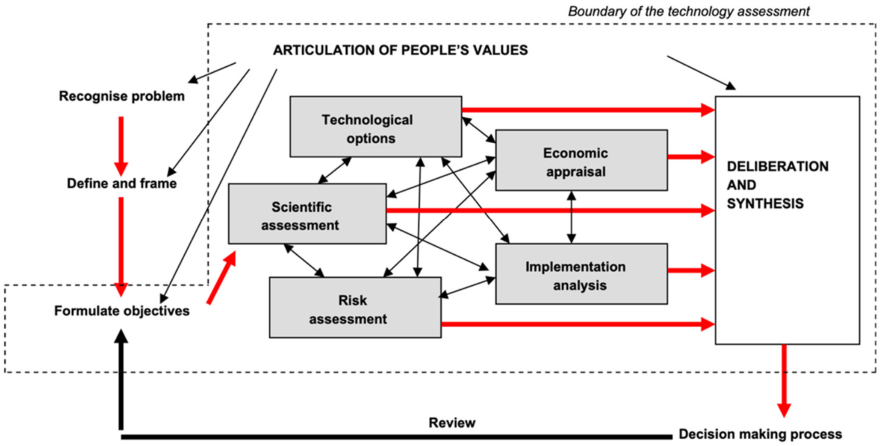

Figure 4 RCEP(1998, 118) technology assessment for bioenergy systems

Benefit of this system is seen in accepting the uncertainty and aiming to resolve such in later stage. It is also seeking for alternative solutions without trade offs and reduces the need for data by aiming to clarifying the terms, making them simple and transparent. It also helps to plan the analysis from bottom up.

2.8 Passengers Factors

Richardson (2005) has over the years been studying the passenger factors affecting sustainability, pointing out five indicators of transport system sustainability – fuel, access, congestion, emissions, and safety, shown on the right side of the diagram. According to Richardson, the system given on the chart can be separated into subsystems by each indicator. It is pointed out that the framework is for passenger transport and would differ from freight transport framework - though both groups are to optimize their functions, differences derive from the economic, temporal, psychological, safety and convenience needs that are typical for humans only.

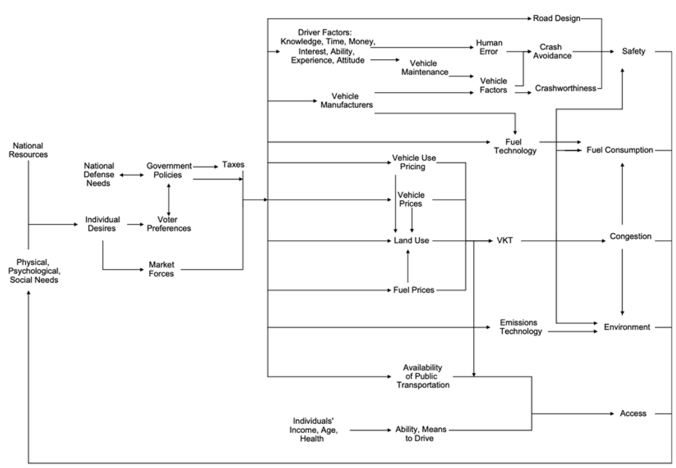

Figure 5 Passenger factors according to Richardson (2005, 29-39)

Funded by the
European Union

Finally, Richardson points to the questions that will need detailed analysis in 8 steps to establish the context, identify different options and criteria, score each option, and weigh each score to define its importance, combining the scores and weights for the results and then finally, examining the results and comparing these with the sensitivity analysis. His questions are best viewed in the following table:

Table 4 Detailed Steps in Undertaking MCDA according to Richardson (DETR 2000, 50)

1. Establish the decision context
1.1. Establish aims of the MCDA, and identify decision makers and other key players
1.2. Design the socio-technical system for conducting the MCDA
1.3. Consider the context of the appraisal

2. Identify the options to be appraised

3. Identify objectives and criteria
3.1. Identify criteria for assessing the consequences of each option
3.2. Organise the criteria by clustering them under high-level and lower-level objectives in a hierarchy

4. 'Scoring': assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion
4.1. Describe the consequences of the options
4.2. Score the options on the criteria
4.3. Check the consistency of the scores on each criterion

5. 'Weighting': assign weights for each of the criterion to reflect their relative importance to the decision

6. Combine the weights and scores for each option to derive an overall value
6.1. Calculate overall weighted scores at each level in the hierarchy
6.2. Calculate overall weighted scores

7. Examine the results

8. Sensitivity analysis
8.1. Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options?
8.2. Look at the advantages and disadvantages of selected options, and compare pairs of options
8.3. Create possible new options that might be better than those originally considered
8.4. Repeat the above steps until a 'requisite' model is obtained

After this initial research, he points out that the follow up is needed to address issues that are not included in the first model of the MCDA and points out the following that would need to be addressed separately:

- Are there other indicators of sustainability that need to be addressed?
- Which factors are not presented in the diagrams?
- How can the impacts of change in technology and policy intervention be measured?
- For which items is more information required so that good decisions can be made?
- What is the efficacy of different technologies, for example, intelligent transport system technologies?
- What methods would best be used to forecast impacts of changes in the influencing variables?
- What would be the impact of analysing sustainability?
- What can be done regarding land use patterns?

Funded by the
European Union

- What is the role of urban sprawl in sustainable transportation systems?
- What are tech roles, responsibilities, and relationships of all participants in the transportation planning and policy setting processes?
- Do these participants need to reach consensus on a vision of a sustainable transport system?
- How do they reach consensus?
- How can behaviour be changed so that people use fewer resources as do those who engage in voluntary simplicity?
- What will be the best ways of changing people's behaviour?
- Can the issue of sustainable transportation be raised into awareness as a public health issue as smoking has?
- What will be the best ways of getting new technology?
- How can public policy be influences to promote a sustainable transportation system?
- What are the key places in the decision process leading to a sustainable transportation system where policy intervention would yield the greatest results?

Within the passenger groups, the accessibility of the transport system to the people with disabilities needs to be addressed separately. There are few literature reviews available on the subject matter – Unsworth et al in 2019 (Unsworth, 2019) and Tapanen et al from 2023 (Tapaninen U, 2023). Unsworth et al have been looking into the use of mobility devices and their accessibility to different transport modes, primarily to the bus transport while Tapanen et al have been looking in comparison to all transport modes, including air and waterways. Both articles agree that additional research on the field is necessary – while the disability types and accessibility has been widely researched, there is little research on the fields of helping people with hearing, communication, linguistic, cognitive, or sensory disabilities with the access to the transport systems.

Though AIRSHIP project is not intended for passenger traffic, the human element might be involved in later stage, so it might be worth while to consider the aspects of passenger needs during the development stage.

2.9 Industry 4.0 and Research Framework

Looking at shipping as part of the supply chain for other industries, one must look also into the Industry 4.0 and how it is merged with the concept of sustainable supply (Bag S. Telukdarie A, 2018). As Industry 4.0 is heavily forcing the digitalization of systems and automation to achieve its main goal, raised productivity, the sustainability of its own supply chain is an important factor on many levels. Bag and Telukdarie suggest in their article to use DCV, Dynamic Capability View to study the Industry 4.0 in terms of driving the supply chain sustainability. As DCV is an extension of resource-based view (RBV), which focuses on how the resources could be turned into dynamic capability resources and hence reconfigure the resources for sustainability in the business environment. They identify the following enablers that must be considered when researching the Industry 4.0 within the context of sustainability:

- Government support
- Support of research institutes and universities
- Law and policy regarding employment
- Improved IT security and standards
- Information transparency
- Standardization and reference architecture
- Management commitment
- Focus on human capital
- Change management
- Horizontal integration

Funded by the
European Union

- Vertical integration
- Corporate governance
- Third-party audits

On the figure 6 below, is the schematic result of their works in term of framework.

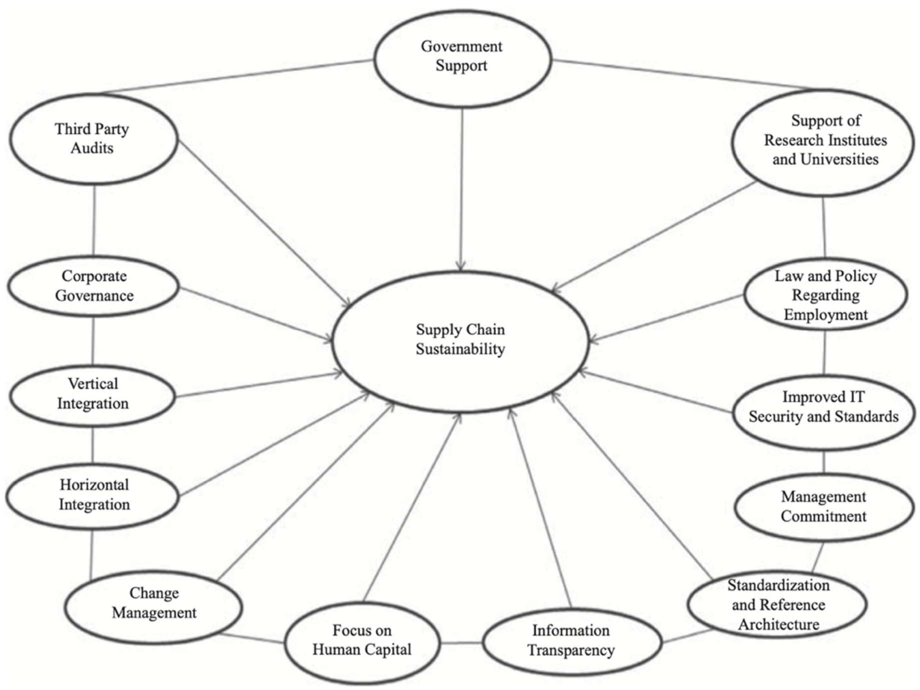

Figure 6 Industry 4.0 framework according to Bag, S. Telukidare, A (2018)

Funded by the
European Union

3 Evaluation of the AIRSHIP Project

According to IMO wing-in-ground vehicles are to be utilised under the same rules as conventional shipping because they operate with other waterborne crafts, therefore the project is mainly evaluated and reviewed as maritime project. (IMO, 2023)

There are many possible views one can take on any maritime project. In following chapters, some possible viewpoints are analysed. However, the work is ongoing and during the coming period will need to be adjusted according to additional findings and development of the project.

3.1 PESTLE Analysis

The PESTLE analysis tool was chosen due to the many components for the assessment of the influencing factors as one of the tools most comprehensive and involving most of the factors influencing any maritime project. PESTLE has been a tool used by several authors as main tool for complex analysis of similar situations (see (Christodoulou, 2019), (Vintila D-F. Filip C, 2017), (Boviatsis B, 2022) etc).
The result based on the literature has been summarized by the authors as can be seen in following figure 7:

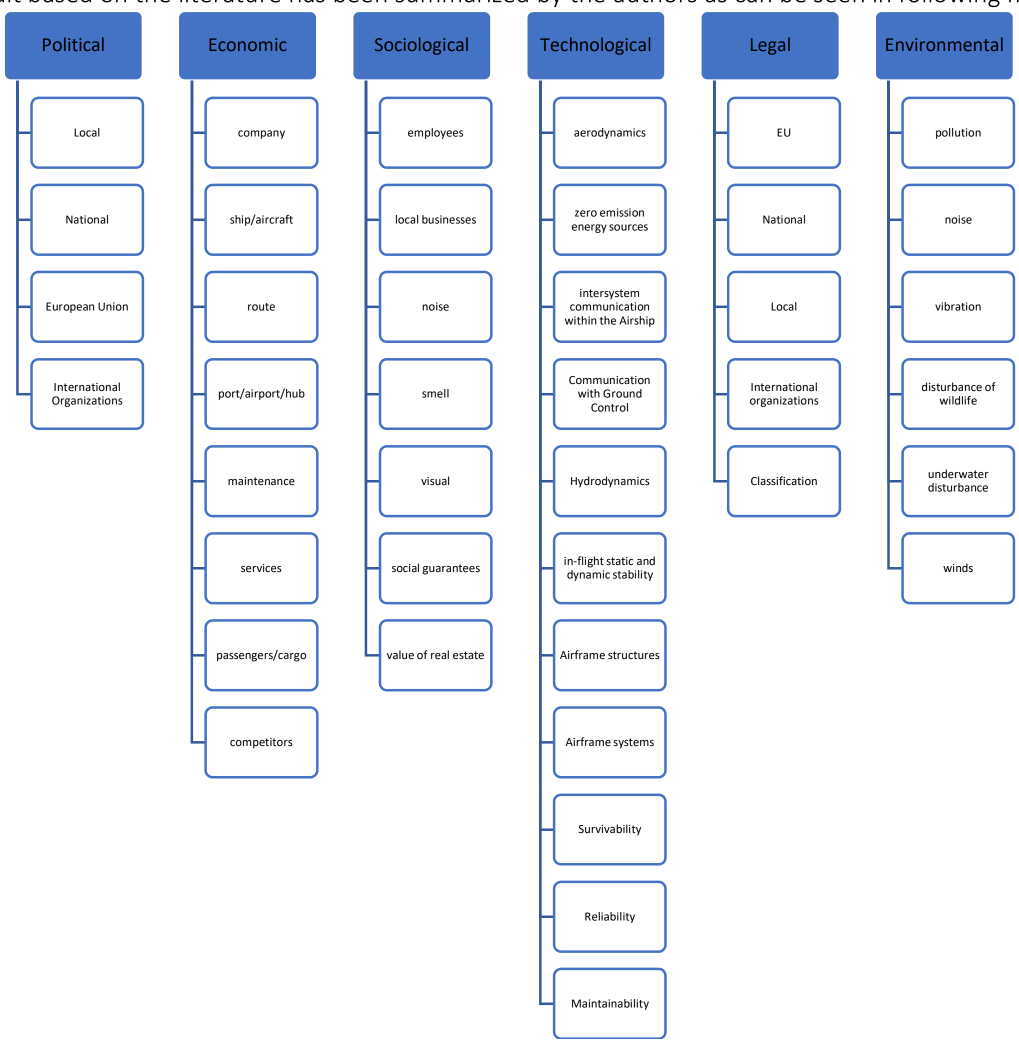

Figure 7 - PESTLE analysis of the maritime project based on literature review results.

Funded by the
European Union

3.1.1 Political Factors

Shipping projects are usually carried out between different countries, affected by various societies, and therefore are under the influence of several levels of political factors. These can be divided into four areas:

Local factors – these may influence the actual location of the port, demands set to the environmental and noise level to the benefit of the local inhabitants. Local policy makers can influence the project through the simplest demands on the various permits to the timing of the entry and exit times to the port, for example.

National factors – changes in the political situation of a country or EU member state can heavily also influence any maritime project. As such projects are carried out over longer term than is usually between the elections, the changes in the political climate after or before the elections can heavily impact the results or even the possibility to carry out or continue with them.

International factors - relations between the countries outside or within the boundaries of international organizations for the third and fourth level of political factors. Disruptions in communications between the countries or cutting the diplomatic ties will have effect on any international projects. As the recent wars have shown, international relations can heavily change the need for the type of ships as well as change the itineraries and even cut down on some destinations and routes. Though the policies of international organizations are upheld only on the countries' approval, the recent wars have shown, these have the effects also on the parties that have not adopted the necessary international laws.

3.1.2 Economic Factors

Classically, the world economy and national economies are setting the environments that are evaluated under the economic factors in the PESTLE analysis. In our case, it has the influence as the demand in shipping is depending on members and the change in the economic environment has the impact on all the members of the market. However, in our case, the new innovative technologies are one of the main aspects that affect the economic factors. New and innovative technologies tend to be expensive at start and that limits their usage to the lesser amount of consumers due to the higher cost that needs to be accepted, especially at the beginning when the not in full performance yet during the implementation phase.

The shipping industry is now on the threshold of changes and break-throughs – there are lots of recent technologies with various aspects being developed that have promising effects on the sustainability. Sadly, none of them is yet in operation and producers and operators of ships are not eager to risk connecting their brands to new, untested technologies (Hoogma, 2002). That poses a risk in taking the steps to implement new technology as it jeopardises the image of the brand and can also create costs that will never be recovered, especially in case the new technology is proven unsuccessful. The economic risk with the new technology is also in the fact that they might prove to be in short supply even in the case of being a success.

Furthermore, in maritime sector, the economic factors can be viewed also separately for each ship, operator/owner, shipping line, port, and related services – unsuccess on any of these fields has the impact on the total result of for all others. For example – the change of the economic environment due to the price changes can mean less demand for transportation. It is complex to make profit in such case even with the most sustainable and lowest costing vessel on the routes where there is no cargo or passengers to carry. And that affects the ports and related service companies as well. These relations deserve to have analysis of their own and will be further analysed when exploring the views of the stakeholders.

Funded by the
European Union

Another field that affects economic factors is connected to aviation and air transport industry. As the WIG craft's speed is between a ship and an airplane, the air transport market situation also affects the success of the project. The impact of air transport market to economic success of AIRSHIP might have both positive and negative influence. Air transport is an important competitor and therefore economic changes in air transport market significantly also affect Airship's economic balance and potential.

3.1.3 Social Factors

Changes in the demographics and needs of the inhabitants as well as their cultural and environmental preferences, especially drastic changes, can also influence the result of the project. As discussed above, the lack of passengers or overflow of passengers has its influence on the shipping line. However, their influence can be not only on the need of travel, but other details that influence their choices – like travel times, comfort of the vessels, interior design and food offered on board or even the entertainment available.

For the seamen, the working environment and the ILO rules connected to the working environment have heavy impact also on any planning of the vessel, same is with the air crew. For years, one of the problems of seamen has been the lack of social contacts while out at sea (Plopa, 2005). With the unmanned shipping, such problems will be solved as the monitoring crew can work from land and there is no need to be on board. However, it also might reduce the workforce needed or set different demands to the qualifications, both of which can create also social problems to the areas where seamanship is common. As the AIRSHIP combines the knowledge of both domains, the operators, and people responsible must have knowledge of both domains. This creates a challenge in training of the personnel.

Implementing new technology is a challenge - it is not easy to change the understanding of the public of which means of transport is accepted and how it should be arranged or what it should look like or cost. The unmanned ships, even if used for the transport of cargo, will have to be accepted by the public. Now, in some countries, the package delivery robots are already accepted while in other countries, these are looked at as means to take work away from people while leaving them to starve. Such understandings and their influence should not be underestimated and need to be researched separately.

3.1.4 Technological Factors

AIRSHIP project brings along many innovations in terms of technological solutions. The AIRSHIP as combination of ship and aircraft, has qualities from both domains. It will need to correspond to the requirements of maritime as well as aviation industry. Hence the following technological possibilities are to be addressed and researched during current project:

- Aerodynamics and hydrodynamics
  Airship will need to have specific aerodynamics to work in ground effect for effective use of fuel and be prepared to land at sea, hence needs to correspond to the requirements of the statical hydrodynamics.
- In-flight static and dynamic stability
  While in flight mode, it needs to be stable and operable for safe cargo transportation.
- Airframe structures and systems
  It needs to be light enough to flight and yet durable enough to land on water, having systems from both domains, maritime and aviation.
- Intersystem communication within the WIG craft and communication between the WIG craft and Ground Control Station /Vessel Tracking Systems.
  All communication systems are to be developed on two directions – within the vessel and its parts as autonomous vessel that can adjust itself based on the decisions taken onboard by AI and using

Funded by the
European Union

corrective actions based on feedback from onboard systems. Second – it should keep contact with flight and vessel control systems (GCS and VTS) as well as be monitored by its handlers onshore.
- Survivability, reliability, maintainability – these three main criteria need to be fulfilled for a successful project already in the phase of tests.

3.1.5 Legal Factors

Any policy and regulatory framework set the rules for all participants of the market. The rule book from the viewpoint of the AIRSHIP project looks complicated and needs to be defined better. However, too strict regulations might prevent risk taking and future developments and implementing the new technologies. Lack of rules, on the other hand, might result in lack of supervision and attention to details such as safety and sustainability. The perfect framework from the legal side therefor would need to be flexible, yet with set rules to maintain equal opportunities to all members of the market and setting the standard of safety and operation equal to all.

The main difficulty with the legal framework for the AIRSHIP is its definition – while having influence on the water, it is still flying above it. The situation has been analysed first by Boganov (1995) and later by Burchevskyy (2009). Burchevskyy defines ekranoplan as a multi-environment vehicle which can either work the best while working in surface effect or, with changes to wingspan, also work as an aircraft. The work of defining them was started by defining the *WIG craft (wing-in-ground craft)* by IMO and ICAO. Result of this is dividing ekranoplans into three different categories:
a) the ones working in surface effect only and therefor completely governed by IMO.
b) the ones which temporarily work outside the surface effect but never over the 150 meters above sea level.
c) the ones which are certified to operate in higher altitudes and must correspond to the regulations of ICAO when working above 150 meters of height and to the regulations of IMO while working under the 150 meters of height. (IMO, 2002)

However, there is several groups of legal scholars who do not agree on the current definition and are in search for more suitable regulations. Furthermore, there is varied approach by countries on the definition of aircrafts. As the AIRSHIP project is aiming for an unmanned WIG, the question of legal definition is furthermore complicated and needs to be thoroughly analysed.

3.1.6 Environmental Factors

While looking at ways to solve environmental problems and ways to reach sustainability, the new technologies also bring new environmental challenges. These need to be analysed in detail when there is more information on the planned fuel and engine types of the AIRSHIP. Classically, the environmental impact of shipping has been divided into three categories: physical impacts, air emissions, and discharges to water (Tombak, 2023). To see the effect of measures used to reduce the impact on environment, there needs to be also a way to assess the ecosystem before and after introduction of new measures.

3.1.6.1 Discharges to Water

Tombak (2023) has distributed the shipping related waste emitted into waters into 14 waste categories – ballast water, oily bilge water, propeller shaft lubricants and/or stern tube oil, tank cleaning and washing water, scrubber discharge, liquid bulk, dry bulk, marine litter/solid waste (paper, plastic, metal scraps etc), garbage and other waste (primarily food/biowaste), black water (sewage from passenger ships), grey water (water from kitchens, showers etc), cooling water of machinery, non-indigenous species (transported to new locations with ships' hulls), biofouling and antifouling paints. However, authors would like to add one more discharge that has been researched in detail by Bosi lately and that carries importance to the Airship project.

Funded by the
European Union

Bosi et al analyse the Maritime Spatial Planning directive in relation to underwater noise (Bosi, 2023). According to them, the analysis of the underwater noise has been conducted in 11 member states of European Union according to the Marine Spatial Planning directive. They have divided underwater noise into two categories – continuous noise (dissipates locally) and impulsive (dissipates over distance). As noise is travelling great distances, it is not limited to the waters of one country, but travel across several national boundaries and jurisdictions, having their effect on many species. As such plans have been done first time, the underwater noise is not sufficiently analysed in these and therefore the possible measures are to be considered yet to be ineffective. Now there is no internationally agreed threshold values, targets, or standard indicators, which will be target of next MSPs (Maritime Spatial Planning). Difficulty lies in the fact that any interaction humans have with waters, the certain level of noise is created.

As AIRSHIP is intended to merely touch the surface during its time of operation, its emissions to the water will be minimal compared to traditional shipping from noise perspective. However, the hull design and operating standards can have impact on other types of waste categories. For example, lack of outer decks minimises the possibility for garbage and similar wastes being emitted.

3.1.6.2 Air Emissions

According to Tombak (2023), the air emissions consist mainly the emissions of the gases – nitrogen, sulphur, greenhouse gases (either fluorinated or not) – and particular matter (organic carbon), black cargon (specific to Arctic areas), ozone-depleting substances and volatile organic compounds.

In addition, noise can also be considered as air emission coming from the vessels, especially at ports. Murphy and King (Murphy, 2014) have come to the conclusions that vessel noise emitted in harbours is above the WHO (World Health Organisation) guideline limits for night-time as well as noise exposure has significant low frequency content.

From the AIRSHIP perspective, the air emissions depend heavily on used engine and fuel types. As the aim is to use the fuels that are not polluting and are low in greenhouse and other gases, the air emissions would be minimal. Provided the AIRSHIP uses electricity from land during its port operations, it would be easy to minimise the noise levels coming from the operation during the port time.

3.1.6.3 Physical Impacts

Tombak (Tombak, 2023) et al. have identified six physical pollution sources – underwater noise, artificial light, collisions with wildlife, waves and currents, ship grounding and sinking and accidents. These are not direct result of shipping operations as the emissions to water, but side effects that occur due to shipping – the sinking ships might emit their fuel due to rusting, the cargo ending in waters after the accident will have their effect on the environment, lights in the harbours and also on ships disturb the wildlife and humans, collisions with wildlife have direct effect on their life expectancy and life quality.

The above-mentioned risks might be also results of the operations of AIRSHIP.

3.1.6.4 Ecosystem Assessment

How to assess the ecosystem is considered a complex interdisciplinary system, as analysed by Basconi and others in their article (Basconi, 2023). As mentioned by Bosi (2023) in their analysis of the MSP directive (EU, Directive 2014/89/EU, 2014), spatial planning and analysis was used also in Basconi's ecosystem assessment as one of the ways to evaluate the results of implementation of MSP directive in Northern - Central Adriatic Sea region. However, they see the basis of the ecosystem evaluation in the UN Convention of Biological Diversity (United

Funded by the
European Union

Nations, 1992). On their analysis they took 7 coastal and marine ecosystems under spatial analysis – tourism, recreational boating, carbon sequestration, coastal erosion prevention potential, mussel and whitefish aquaculture and industrial fishery as these are locally important factors in the area shared by Italy and Croatia. Used research method was questionnaires, mapping and eco-physiological and bioenergetic box models. In addition, the model created by Liquete et al. (2013)was used for analysing coastal erosion potential, summary of which can be seen on Figure 8. However, their conceptual framework given on the picture below as a scheme can be adjusted also to other fields of interest.

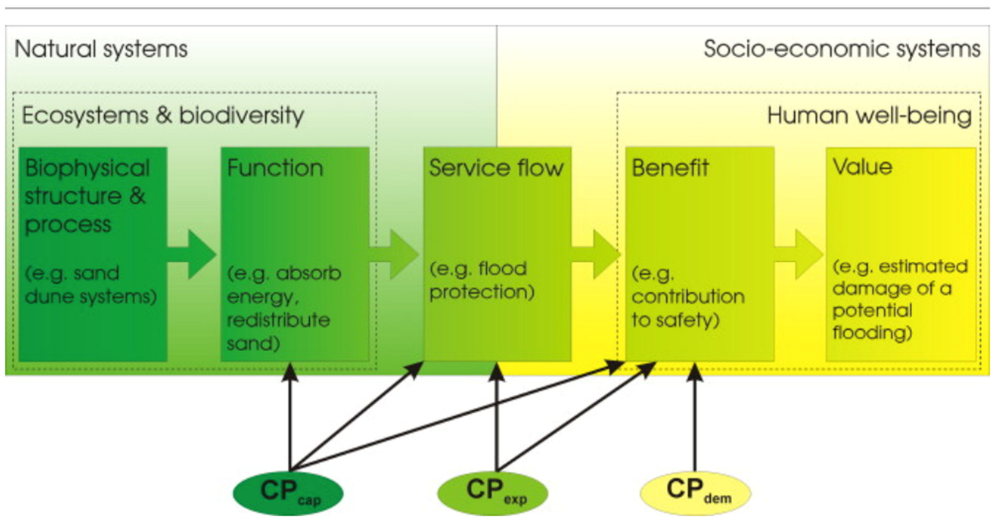

Figure 8 Conceptual framework of Liquete (Liquete, 2013)

As a result of their study, they have represented a correlogram of the relations between erosion and the use of the maritime areas coming to conclusion that if sustainable management strategy has been created and it

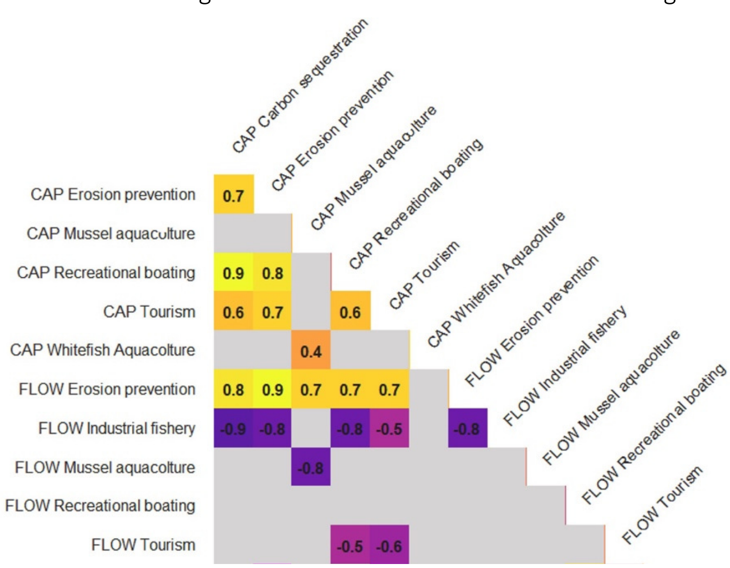

Figure 9 Relations of the industries and their effect on each other (Chen P, 2023)

Funded by the
European Union

includes also cultural services and provisioning, it should also include economic and social driver to achieve sustainability at all levels. Nevertheless, they find that balance between different ecosystems and use of the system is the best - should for example tourism be overwhelmingly maximised in certain place, it will bring along lack in the other areas, for example in erosion prevention and therefor in the end, endanger human well-being. This is supported by the Chen et al research of seawater quality and its changes through the protection policies (Chen P, 2023). They carried their assessments out in the heavily trafficked Xiamen Bay, and they find a strong correlation between the economic development and seawater quality showing direct influence of protective regulations. The period analysed was 2007 to 2018 with 10 monitoring sites used. In 2015, the plan of pollution control was introduced in the area and the effects of such regulation became almost instantly visible also in nature, by reduced amounts of DRP, COD and DIN indicators, as can be seen on Figure 9.

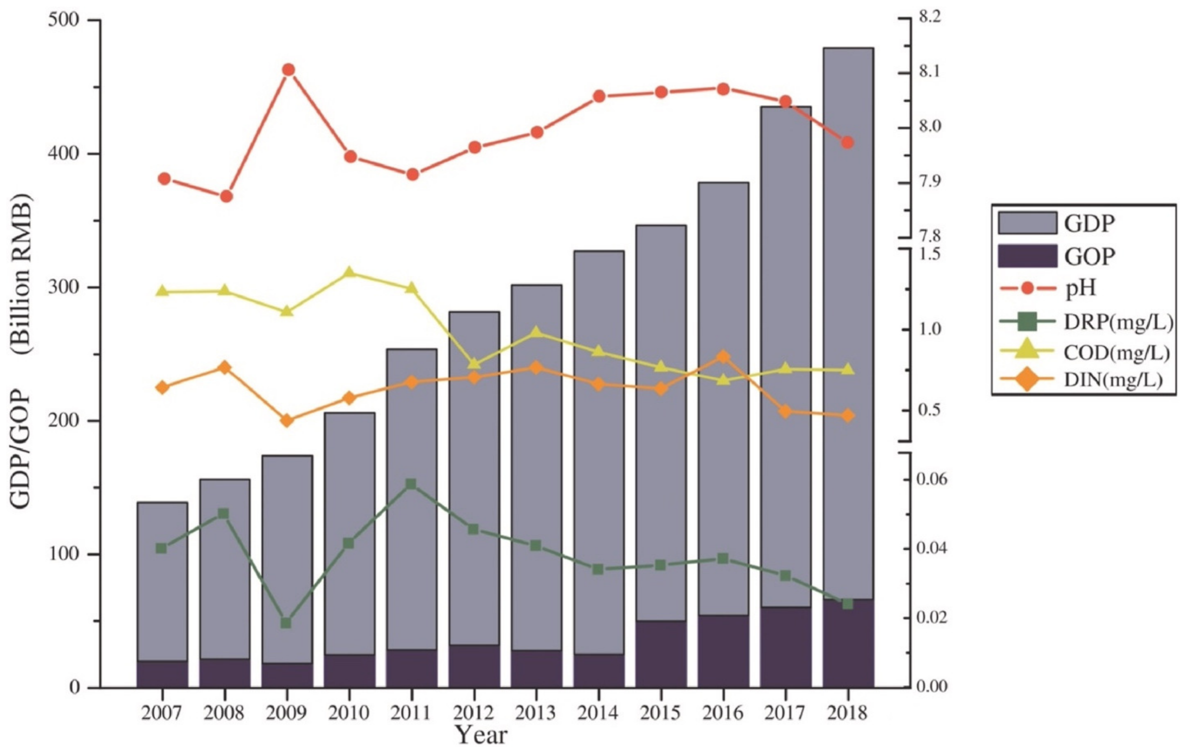

Figure 6 - Changes of seawater and the effect of the regulations (Chen, 2023)

3.2 SWOT Analysis

While PESTLE analysis gives overview of the outer factors that can influence the project, it might be necessary to also complete the SWOT analysis on the project to evaluate the internal factors that can make a project either a success or a failure. Similar analysis model has been used by Christodoulou et al while looking into the sustainability of port systems (Christodoulou, 2019).

3.3 Stakeholder Views

One possible way to evaluate the project is through the positions of the stakeholders and their expectations. The list of stakeholders could be modified as the project progresses, and more involved parties are defined.

Funded by the
European Union

All shipping projects involve many partners – owners of the ships, ship operators, local communities and ports within the communities, regulators, employees etc. In this chapter we analyse the possible ways AIRSHIP project is involved in each of them and give the literature review of each of these areas.

3.3.1 Owners and Operators

The owners' viewpoint is always connected with taking maximum economic gain of the vessel or the craft with minimal costs. Sustainability in their case is often only implemented if this is demanded by governments or if it is useful to the owner itself. However, should the sustainable solution be optimal and economically profitable, it is of definite interest to the owners and the operators.

3.3.2 Employees

Shipping influences heavily the personnel on board. As this project is planned without persons living onboard the vessel, it removes one of the main hazards of employees living on board of the ships, lack of contact with their families during the working period.

However, this type of ship will need personnel with different skills than ordinary seamen – there will be need for the land-based monitoring system, programmers and system administrators that are dedicated to the operation of the airship.

3.3.3 Local Communities

Any shipping project needs to follow the need of transport of either goods or services. That means connecting communities. And it also means involving all these who are under the influence of the services – both public and private sector bodies. The more people are involved in the decision-making processes from the early business development, the easier is the acceptance of possible side effects like additional light or noise. (Tombak, 2023)

3.3.4 Regulators

While looking at the sustainability of shipping from the viewpoint of regulators, very often the cost of regulating is overlooked (Cavender-Bares, 2015). When there are detailed regulations in place, there is usually involved also cost of monitoring. Cost of monitoring again is a burden on society – the personnel costs as minimum, but also on the environment – like driving to the place of monitoring or even having the computers to monitor.

3.3.5 Production Facilities

Production facilities can be looked at from three viewpoints – as initial builders of the ship, they are largely the influencers of the size of its carbon footprint is before it is even launched in the waters. Second, their role as repair and upgrade facility during the lifetime of the ship. And third, the dismantling facility. However, according to Vakili and others (Vakili, 2023), the production facilities should be looked at as part of urban society and as one of the polluters whose actions can be changed on several levels to turn them into zero emission stations and hence in total reduce the negative impact of the maritime industry. By reducing emissions already in the production phase to zero would result the ships of having zero emissions at the start of their sailing life instead of having negative balance at the start.

3.3.6 Ports

Ports are important in regard of sustainability in many areas:

- Providing land-based electricity reduces the emissions in harbours as well as noise levels.
- Providing waste management solutions ((BSAG, 2023)
- Providing possibilities to bunker low carbon fuels.
- Facilitating just-in-time arrivals and departures,
- Promoting the use of electronic data exchange and digital solutions (IMO, Resolution MEPC.323(74), 2010)

Also, from the viewpoint of the environment, the location of the port and its influence on the habitat is important both to the humans and wildlife living in the area. The detailed analysis of the suitable ports and their services need to be conducted once the project has advanced to the practical stage.

4 Integrated Sustainability Assessment Framework for AIRSHIP

In today's world, there is a growing emphasis on the importance of sustainability, particularly the development of products that aligns with economic, environmental, and societal requirements. The way technologies are evaluated during the early stages of design plays a critical role in successful integration of sustainability into innovation activities. This is a vital progression towards the creation of products and procedures that yield more favourable economic, environmental, and social outcomes (Parolin G, 2024). Therefore, we attempted to develop initial sustainable assessment framework supported by the possible performance parameters specific to AIRSHIP, aiming to enrich the environment, economic and social angle of the project. This framework can latterly be utilized for further purposes, including the initiation of the new business model for AIRSHIP, as well as the analysis associated business cases.

To do this, first possible key performance criteria were determined through extensive literature review. The indicators were classified under the three pillars of sustainability. Then business model logic of Osterwalder et al. (2005) was integrated to create sustainable assessment framework. Thus, the initial version of sustainability framework can be employed for further analysis of the AIRSHIP specific business cases.

4.1 Identification of Sustainable Key Performance Indicators

Systematic literature review was used to determine the key performance indicators by organizing the papers in a three-step protocol; namely data search, data analysis and reporting (de Almeida Biolchini, 2007). In data search process, the review protocol was developed to paper inquiry in accordance with the aim and several criteria was set for the aim of achieving direct results. To increase the reliability, and to ensure paper quality Web of Science (WoS) and Scopus databases were selected for the query. and the same research string (("key performance indicator*" AND "sustainab*" AND ("shipping*" OR "aviation*") AND ("measur*" OR "assessment*")) was used in both databases. Keyword search query was performed regarding only articles in English texts. This query yielded 7 results in WoS, and 18 results in Scopus. After elimination of duplicated articles, 25 papers achieved through the query.

In data analysis process, abstracts of each paper were initially screened to check the relevance of the papers with the topic. Then the possible indicators for the AIRSHIP were selected and deductively categorized under sustainability pillars. In selection process, we focused solely on the measurable items. Table 5 illustrates the sustainability KPI's for AIRSHIP.

Funded by the
European Union

Table 5 - The summary of KPIs for AIRSHIP, compiled by authors.

Sustainability Pillar	Type	Name	Units	Description	SDG involved
Environmental	Emission	Co2	Kg of CO2/tkm	CO2 emissions	3.9. 14.1
		NOX	Kg of NOx/tkm	Nox emissions	3.9, 14.1
		Sox	Kg of SOX/tkm	SOX emissions	3.9,14.1
		PM	Kg of PM10/tkm	PM10 emissions	3.9. 14.1
		Waste	Kg	Amount of waste produced	3.9, 12.2, 12.4, 14.1, 14.2
		Acoustic noise above the sea level	DB	Noise emitted at sea	3.9
		Acousting noise under the sea level	DB		3.9, 14.1,14.7, 15.8
		Acoustic noise at terminals	dB	Amount of noise emitted by vessel and terminal operations	3.9. 11.a
		Light pollution	Lumens/shipment	Brightening of the night sky caused by operations	3.9, 11.a
Economical	Finance	Revenue	EUR/km		
		Capex	EUR	Capital expense	
		Opex	EUR	Operating expense	
		Insurance	EUR/year		
		Maintenance costs	EUR/h	Expenses to ensure the correct and reliable operation of an asset	
		Periodical Costs	EUR/h		
		Port charges	EUR	Fees paid to port authorities	
		Fuel cost	EUR	Total amount of money spent in fuel	12.c
	Energy	Use of renewable energy sources	%	Emission	7.1, 7.2, 7.a, 7.b, 9.4

		Battery Cost (instalment)	EUR/kWh		
		Energy consumption	Kwh	Total energy needed	7.b
		Energy consumption by unit	Kw/TEU	Total energy needed for movement of one transport unit	
		Battery Specific Power	Wh/kg		7.b
		Cargo Energy Efficiency	kWh/ton	The energy (in kilowatt-hours) needed to carry one ton of cargo a certain distance at a constant speed	7.3
		Battery lifetime	EUR/h		
		Peak Efficiency Speed	knots	Speed where the boat is most energy-efficient	
	Operational cost	Part Replacement	EUR/h		
		Craft Lifetime	EUR/h		
		Terminal area per cargo unit	M2/cargo unirt	Land needed to perform operations as funtion of the cargo moved	
	Ratio	Cost-Efficiency Ratio			11.2
		Net Present value (NPV)		present value of the future costs from the present values of cash incomes over project lifespan	
		EBITDA	EUR	Earnings before interests, taxes, depreciation and amortization	
		ROI	EUR	Return on Investment	
	Market capture	Required Freight Rate	EUR/(ton, passenger,TEU)		11.2
		Cargo carried	TEU/Ship	Cargo carried from loading to discharging	2.1
		Traffic	€TEU/port call	Amount of goods transported in ports/terminals	12.6

	Service level	Loading/unloading time	H	Duration of the loading and unloading process	
		Sailing time	H	Duration of the vessel voyage	2.1
		Waiting time	H	Time during which cargo is idle	
		Recovery time	H	Time from disruption detection to full restoring of performance	9.1
		Cargo handling time	TEUs/H	Time to move goods on and off ships plus terminal handling time	2.1
		Down time	D/Y	Days per year the vessel is not in operation due to weather limitations	9.1
		Punctuality rate	%of port calls	Deviation from expected arrival/departing time	9.1
Social	Safety	Complaints	Nr	Total number of society and local complaints	
		Customer satisfaction score	%	Feedback level of the customer satisfaction	
		Accident rate	Number	Incidents resulting in damage or injury	
		Fatality rate (Passenger Injury Rate)	Number	Occurrences of death by accident	
		Fire incidents	Number	Incidents involving smoke, heat flames causing damage	
		Navigational Incidents (Rialland et al.	Number	Incidents resulted by the navigational errors	
		Cargo related incident	Number		
		Crime	Number	All actions which constitute and offence and is punishable by law	
		Cyber incidents	Number	AmountNumber of cyber incidents occurred and managed	
		Perception and awareness of coastal communities towards risk management	NA		11.a

	Regional	Expected develoments related to AIRSHIP	NA		11.a
	Work	Labour conditions	Work-life balance	Quality of working environment	3.4
		Employement	%of change	Influence of occupational rate	8.2
		Income	%of change	Influence of earnings	8.5
		Worker commuting time	Distance ship-home	Total journey employees take from home to work and back again	
		Training	Time/staff	Time invested in teaching employee a particular working skill	8.6
		work accidents	Time/staff		3.4, 3.6
		Personell	Nr	Number of officers onboard	

Table 6 - Measurables of the project AIRSHIP, compiled by authors.

4.2 KPI-Based Sustainable Value System Proposal

A business model is a conceptual tool that encompasses a collection of elements and their interrelations. It serves to describe how a particular company delivers value to one or multiple customer segments. Additionally, it outlines the structure of the company and its network of partners involved in creating, marketing, and delivering this value. The ultimate objective is to generate sustainable and profitable revenue streams while nurturing valuable customer relationships (Osterwalder, 2005). A business model serves as a framework that explains the rationale and presents supporting data and evidence for how a company generates and delivers value to its customers. Additionally, it delineates the structure of revenue, costs, and profits associated with the business as it delivers the value (Teece, 2010). Business model development is also essential in product/technology development efforts, as the value created by the innovation and the extension of value to broader range of stakeholders determine the sustainability of innovations. Business model is generally defined by the scholars combining three perspectives: value proposition, value creation and delivery, and value capture (Rachinger et al. 2019; Osterwalder and Pigneur, 2010; Morris et al., 2005; Teece, 2010; Saebi et al. 2017). It all begins with understanding how customers perceive value, which serves as the basis for creating appealing value propositions. Next, the organization must determine the most suitable methods for delivering this value to the market effectively. Finally, in the value capture phase, the organization's pricing strategies and revenue sources take centre stage, influencing how it translates the value it provides into financial gains.

Sustainable business model is a practical manifestation of a company's commitment to sustainability, as guided by a sustainable business framework. The framework provides the overarching principles and goals, while the business model translates these into specific strategies and actions that drive sustainability throughout the organization. Together, they form a cohesive approach that helps businesses address social and environmental challenges while ensuring their long-term success (Hart S L, 2003). On the other hand, key performance indicators are essential for a sustainable business framework because they provide the means to measure, manage, and improve sustainability performance. They help organizations stay on track with their sustainability objectives, foster accountability, and enhance communication with stakeholders, ultimately contributing to long-term success and positive societal and environmental impacts. Thus, the perspectives of a sustainable business framework, a sustainable business model and AIRSHIP specific KPI's were combined to delineate how the AIRSHIP is committed to sustainability. To propose KPI-based sustainable value system for AIRSHIP each KPI's evaluated within value proposition, value creation and delivery, and value capture perspectives. Figure 7 illustrates the schematic representation of proposed model.

Funded by the
European Union

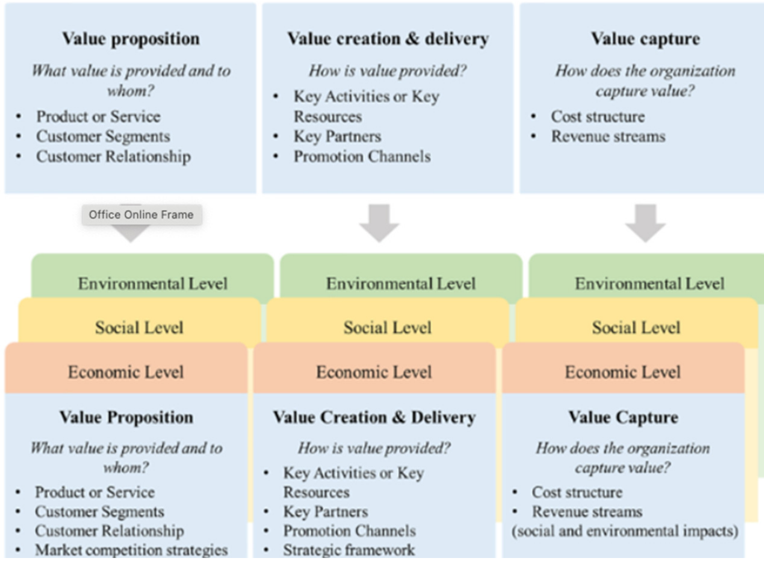

Figure 7 - Conceptual model of KPI-based sustainable value system model for AIRSHIP (Joyce and Paquin, 2016) (Sousa-Zomer & Cauchick M, 2018), (Cui et AL, 2021)

Based on the AIRSHIP specific Sustainability KPI's and the business model innovation perspective, Table 6 shows the proposed value system for AIRSHIP.

Funded by the
European Union

Table 7 - Proposed value system for AIRSHIP, compiled by authors.

	Sustainability Pillars		
Value Dimensions	Economical	Environmental	Social
Value Proposition	Financial Stability: Ensure revenue consistency and capital efficiency for long-term fiscal sustainability in maritime technology Risk Management: Fortifying business resiliency with comprehensive insurance as a cornerstone of sustainability and incorporate comprehensive insurance to mitigate risks inherent to AIRSHIP technology innovation Efficient Operations: Optimize operational costs, including maintenance, energy to enhance sustainability of AIRSHIP technology Financial Viability: Maintain a positive trajectory for EBITDA and ROI, indicative of sustainable financial health in AIRSHIP technology development Sustainability as a Selling Point: Utilize environmental sustainability as a competitive advantage to attract environmental-friendly stakeholders Operational Excellence: Prioritize operational efficiency to establish the AIRSHIP as a benchmark in the industry Safety Assurance: Emphasize rigorous safety protocols to underline the AIRSHIP's	Emission Reduction: Achieve cleaner AIRSHIP operations with targeted reduction in emissions and waste Noise Reduction: Achieving quieter AIRSHIP operations in the area	Safety Prioritization: Using safety parameters to prioritize safety measures and reduce risks, creating a safer environment for Safety: Enhanced safety systems to minimize accident and fatality rates. Efficiency: Streamlined cargo management and advanced anti-crime/cybersecurity measures. Community Focus: Engagement strategies with coastal communities for improved risk management

	commitment to risk management in marine environments Competitive Pricing: Align pricing strategies with operational efficiencies and environmental achievements Top-tier Customer Service: Deliver superior customer support to build trust and loyalty in advanced AIRSHIP solutions		
Value Creation and Delivery	Revenue Growth: Accelerate revenue via market penetration and offerings specific to AIRSHIP Capital Efficiency: Maximize returns on capital with prudent investment Cost control: Enhance profitability through streamlined maintenance, energy efficiency, and operational efficiency Risk Mitigation: Enhancing safeguard operations and extending the risk mitigation measures and insurance coverage Long-Term Viability: Ensure the enduring success of AIRSHIP tech with solid financial metric Sustainability Focus: Commitment to the eco-efficiency and meeting green standards Customer-Centric KPIs: Align performance indicators with client-focused service enhancement	Emission Reduction and Control: Enabling to adopt advanced propulsion system and use clean energy with AIRSHIP technology Waste Efficiency: Minimizing environmental impact and reducing disposal costs by implementing proper practices Noise Mitigation: Mitigating the noise through the technologies used developed for AIRSHIP Light Pollution Reduction: Contributing to the preservation of natural nightscapes and wildlife habitats	Eco-Friendly Operations: Commit to sustainable operations with a lower environmental footprint. Cutting-Edge Tech: Deploy latest navigation and safety technologies to increase safety in navigation Costs: Attract and retain skilled workers through improved labour conditions, competitive employment terms, and reduced commuting times, ultimately reducing recruitment costs

	Competitive Pricing: Balance competitive rates with sustainable profit margins in AIRSHIP Energy Efficiency: Energy efficiency for sustainable AIRSHIP operations		
Value Capture	Market Expansion: Expand into new markets or customer segments Enhanced Offerings: Offer premium features or services for additional revenue Risk Management: Minimize insurance claims through proactive risk reduction in AIRSHIP Predictive Maintenance: Use predictive maintenance to prevent costly malfunctions Port Authority Relations: Negotiate sustainability-linked incentives with authorities Operational Efficiency: Streamline processes to reduce inefficiencies Marketing and Sales Efficiency: Sharpening sales strategies and optimising marketing to grow AIRSHIP cost effectively	Market Differentiation: Tending to the customer segments that might be willing to pay premium prices for the environmentally friendly services Regulatory Compliance: Ensure the meeting and exceeding the requirements of environmental standards which helps to avoid potential penalties and legal issues Cost Saving: Enabling the cost saving in the long run by adopting sustainability measures (e.g., energy efficiency) Brand Reputation: Elevating the brand with a commitment to environmental responsibility, gaining customer loyalty and trust which means increased sales and profit	Premium Positioning: Market as a leader in safety and sustainability. Revenue Diversification: Offer sales, leasing, and comprehensive maintenance contracts. Strategic Alliances: Build partnerships for market expansion. Brand Development: Establish as a top-tier brand in maritime safety and innovation. Sustainability Focus: Leverage eco-certifications for market and regulatory advantages.

4.2.1 Sustainability-Based Value proposition System

In the economic sustainability axis, AIRSHIP specific value might be offered promoting financial stability, risk management, efficient operations, financial viability, operational excellence, safety assurance competitive pricing, promoting sustainability related activities and providing excellent customer services specific to customer segments. In financial manner, the focus on consistent revenue generation and capital efficiency ensures a resilient business model, underpinned by comprehensive insurance that manages risk and supports the innovative nature of AIRSHIP. Prioritizing cost optimization in operations, maintenance, and energy usage, AIRSHIP not only commits in fulfilling sustainability promises, but also contributes to economic sustainability, as reflected in robust EBITDA and ROI metrics. Moreover, the sustainability related outcomes that AIRSHIP proposes, can be leveraged as a unique selling point, appealing to environmentally conscious stakeholders, and setting a benchmark in the industry for operational excellence and innovation. Operational efficiency and environmental achievements allow to offer competitive prices. Operational efficiency is further bolstered by rigorous safety protocols, which not only ensure compliance with industry standards but also reinforce the company's dedication to risk management in challenging marine environments. These elements of the value proposition are strategically designed to build trust, foster loyalty, and establish AIRSHIP solutions as the preferred choice, thus enhancing its competitive position in the maritime technology landscape.

Environmental sustainability perspective, AIRSHIP presents a multifaceted value proposition with clear environmental benefits. Emission reduction efforts signify a substantial decrease in environmental impact, aligning with global sustainability targets and providing measurable benefits in terms of air quality and waste management. Noise reduction initiatives deliver significant quality of life improvements for local populations and ecosystems, presenting a strong case for the AIRSHIP's integration into environmentally sensitive areas.

AIRSHIP likely to propose the benefits in safety, operational, and community engagement. From a safety perspective, the introduction of advanced safety protocols and systems markedly reduces the risk of accidents and fatalities while enhancing the reliability and reputation of AIRSHIP operations Operational efficiency, achieved through streamlined cargo management, and strengthened cybersecurity, offers direct economic benefits to customers by optimizing delivery times and ensuring cargo security, which in turn can drive customer satisfaction and retention.

4.2.2 Sustainability-Based Value Creation & Delivery System

Value creation and delivery strategies and implications for AIRSHIP highlight the different strategies which integrates market penetration, capital efficiency, cost control, risk mitigation, long-term viability, sustainability, customer centric KPIs, competitive pricing, and energy efficiency. By blending these elements, a holistic strategy might be determined for not only addressing immediate business goals, but also sustaining itself within dynamic environment.

Possible revenue generation strategy of AIRSHIP innovation is market penetration and tailored offerings, thereby delivering value by meeting specific customer needs and expanding its market presence, thereby accelerating revenue. Risk mitigation is another critical component, enhancing reliability and customer trust through strengthened operations and comprehensive insurance coverage. This aspect is closely tied to AIRSHIP's commitment to long-term viability, ensuring the company's endurance in a rapidly evolving market.

Funded by the
European Union

AIRSHIP's environmental strategy is a comprehensive approach focused on reducing emissions through advanced propulsion and clean energy, improving waste management to minimize environmental impact, implementing noise-reducing technologies to better community living conditions, and actively working to decrease light pollution. Those can be actively used for creating and delivering value.

In addition to its commitment to environmentally friendly operations, AIRSHIP can add value by prioritising cutting-edge technology in the areas of navigation and safety. AIRSHIPS's strategic focus on the workforce is to reduce turnover and recruitment costs, ensuring a stable and experienced team to deliver a high-quality service, thereby maintaining, and enhancing customer satisfaction and operational reliability.

4.2.3 Sustainability-Based Value Capture System

Like value proposition, value creation and delivery frameworks, value capture framework for AIRSHIP can be structured based on a holistic strategy integrates market expansion, operational efficiency, and brand excellence. Expanding into new customer segments and offering premium services enhances revenue while reinforcing the brand's leadership in safety and sustainability. Risk management and predictive maintenance can reduce operational costs and insurance claims, boosting profitability. The sustainability credentials of AIRSHIP technology can be used as a point of differentiation that also provides building a significant brand identity.

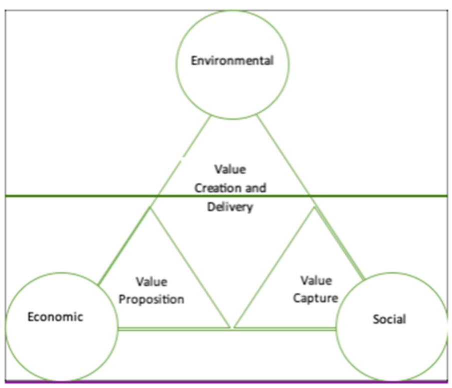

Figure 8 - Airship Value System - KPI Integrated Sustainable Business Framework for AIRSHIP (created by authors)

5 Conclusions and Future Works

This deliverable report introduces various ways of assessing maritime projects and generates integrated sustainability assessment framework for AIRHSIP project.

The framework is the basis of assessing the sustainability, nevertheless during the project execution it might be relevant to be developed depending on the processing and progression of the different phases.

This integrated sustainability model framework considers environmental, economic, and social aspects of the proposed AIRSHIP technology and shows which are the essential parameters to be considered.

Funded by the
European Union

Figure 9. EU Flag.

Funded by the
European Union

Bibliography

Merriam Webster's Dictionary. (2012).

United Nations. (1992). Retrieved 07 2023, from Convention on Biological Diversity: Home: https://www.cbd.int

EU. (2008). *Directive 2008/56/EC.* Retrieved from Eur-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2008.164.01.0019.01.ENG&toc=OJ%3AL%3A2008%3A164%3ATOC

EU. (2014, 07 23). *Directive 2014/89/EU.* Retrieved from Eur-Lex: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0089

Chofreh AG, G. F. (2017). Review of Frameworks for Sustainability Implementation. *Sustainable Development*, 180-188.

Wallace, A. R. (1890). *A Narrative of Travels on the Amazonand Rio Negro: With an Account of the Native Tribes, and Observations of the Climate, Geography, and Natural History of the Amazon Valley.* London, New York and Melbourne: Ward, Lock and Company.

TR, M. (1992). *An Essay on the Priciple of Population.* Cambridge.

Trapaga-Monchet K, A.-R. A. (2023). *Roots of Sustainability in the Iberian Empires Shipbuilding and Forestry, 14th–19th Centuries.* Routledge.

Farley, H. M. (2014). *Sustainability. If it's everything, is it nothing.* Routledge.

Cavender-Bares, J. P. (2015). A sustainability framework for assessing trade-offs in ecosystem services. *Ecology and Society, 20*(1).

Bag S. Telukdarie A, P. J. (2018). Industry 4.0 and supply chain sustainability: framework and future research directions. *Benchmarking: An International Journal*.

Richardson, B. C. (2005). Sustainable transport: analysis frameworks. *Journal of transport Geography, 13*, 29-39.

Elghali, L. C. (2007). Developing a sustainability framework for the assessment of bioenergy systems. *Energy Policy, 35*, 6075-6083.

Pucher J, B. R. (2017). Cycling towards a more sustainable transport future. *Transport Reviews*.

Lingqun, L. (2023). Building Up a Sustainable Path to Maritime Security: An Analytical Framework and Its Policy Applications. *Sustainability*(15(8)).

Chen P, C. H. (2023). Quantitative assessment of the response of seawater environmental quality to marine protection policies under regional economic development --A case study of Xiamen Bay, China. *Marine Environmental Research, 186*.

Vakili, S. S. (2023). The road to zero emission shipbuilding Industry: A systematic and transdisciplinary approach to modern multi-energy shipyards. *Energy Conversion and management: X, 18*.

Liquete, C. Z. (2013). Assessment of coastal protection as an ecosystem service in Europe. *Ecologiclal Indicators, 30*, 205-217.

Basconi, L. R. (2023). Ecosystem services for supporting coastal and marine resources management, an example from the Adriatic sea (Central Mediterranean sea). *Ocean & Costal Management, 235*.

Bosi, S. R. (2023). Is Maritime Spatial Planning a tool to mitigate the impacts of underwater noise? A review of adopted and upcoming maritime spatial plans in Europe. *Marine Policy, 155*.

Paramana Th, D. M. (2023). Achieving coherence between the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive. *Marine Policy, 155*.

Ha S, J. B. (2023). A framework for determining the life cycle GHG emissions of fossil marine fuels in countries reliant on imported energy through maritime transportation: A case study of South Korea. *Science of The Toatal Environment, 897*.

Karountzos, O. K. (2023). A Decision Support GIS Framework for Establishing Zero-Emission Maritime Networks: The Case of the Greek Coastal Shipping Network. *Jouranl of Geovisualizetion and Spatial Analysis*(7).

Funded by the
European Union

Zis, T. H.-V. (2023). Design and application of a key performance indicator (KPI) framework for autonomous shipping in Europe. *Maritime Transport Research, 5*.

Auer S, N. S. (2022). Towards blockchain-IoT based shared mobility: Car-sharing and leasing as a case study. *Jouranl of Network and Computer Applications, 200*.

Aden QA, Z. J. (2022). Public Preferences Towards Car Sharing Service: The Case of Djibouti. *Fronetiers in Environmental Science, 10*.

Safdar M, J. A.-A. (2022). Analysis of the influential factors towards adoption of car-sharing: a case study of a megacity in a developing country. *Sustainability, 14*(5).

Hoogma, R. K. (2002). *Experimenting for Sustainable Transport.* New York: Routledge.

Sandom C, F. S.-S. (2014). Global late Quaternary megafauna extinctions linked to humans, not climate change. *The Proceedings of The Royal Society B, 281*(1787).

Hartwick, J. (1967). Intergenerational Equity and the Investing of Rents from Exhaustible Resouces. *American Economic Review*, 972-974.

Martinet, V. (2004). The Hartwick rule and the characterization of constant consumption paths in the presence of an exhaustible resource. *Prepint of Conference SURED, young economists session.* Paris: THEMA.

Asheim, G. B. (1994). *Sustainability - Ethical Foundations and Economic Properties. Policy Research Working Paper 1302.* The World Bank.

Brundtland, G. e. (1987). *Report of the World Commission on Environemt and Development: Our Common Future.* United Nations.

Hoffman, A. J. (2003). Linking social systems analysis to the industrial ecology framework. *Organization & Environment, vol 16 (1)*, 66-86.

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

British Standards Institution, B. (2009). BS 8901:2009 Specification for a sustainable management system for events. Great Britain.

Christodoulou, A. C. (2019). Identifying the Main Opportunities and Challenges from the Implementation of Port Energy Management System: A SWOT/PESTLE Analysis. *Sustainability*.

Vintila D-F. Filip C, S. M.-I.-D. (2017). A Political, Econmic, Social, Technology, Legal and Environemntal (PESTLE) approach for Maritime Spatial Planning (MSP) in the Romanian Black Sea. *Inernational Conference on the Management and Industrial Engineering.* Bucharest.

Boviatsis B, V. G. (2022). Correlation of the Concepts of Proactiveness and Due Diligence to Achieve Sustainability in the Maritime Sector. *Journal of Shipping and Ocean Engineering*, 33-42.

Plopa, M. (2005). *Psychological studies of stress experienced by seamen during a long-distance sea voyage.* Warsaw, Poland: University of Finance and Management.

Bogdanov, A. (1995). THE PROBLEMS OF EKRANOPLANS CERTIFICATION. CONCEPTION AND DEVELOPMENT OF IMO SAFETY REQUIREMENTS. *Workshop on Twenty-First Century Flying Ships.* Sydney, Australia.

Burchevskyy, O. (2009). *Are we ready to drive to the sky?: personal air- land vehicles within the modern air law framework and Theory of Legal Innovation.* MCGill University, Institute of Air and Space Law.

IMO. (2002). *Interim guidelines for wing-in-ground (WIG) craft.* IMO.

BSAG. (2023). *SHIP WASTE ACTION INITIATIVE IS TURNING INTO STANDARD PROCEDURE AT PORTS.* Baltic Sea Action Group, www.bsag.fi.

IMO. (2010). *Resolution MEPC.323(74).* IMO.

UN. (1992). *Agenda 21.*

UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.*

Murphy, E. K. (2014). An assessment of residential exposure to environmental noise at shipping port. *Environmental International*, 207-215.

Tombak, M.-L. T. (2023). Shipping Related Activities and Their Environmental Impact - Lessons Learnt from the Estonian Case Study. *Transnav*.

Funded by the
European Union

Unsworth, C. S. (2019). A systematic review of public transport accessibility for people using mobility devices. *Disability and Rehabilitation, 43 (16)*, 1-15.
Tapaninen U, e. a. (2023). Accessibility of public transport for people with disabilities: A systematic literature review. *Transport*.
BIMCO. (2023). *Shipping KPI's*. Retrieved 11 2023, from https://www.shipping-kpi.org
Nesheim, D. F. (2019). Using the BIMCO Shipping KPI Database to identify costs and benefits of e-navigation solutions. *SINTEF*.
ICAO. (2023, 11 14). *KPI's*. Retrieved from https://www4.icao.int/ganpportal/ASBU/KPI#.
UNCTAD. (2017). *UNCTAD Framework for sustainable Freight Transport (UNCTAD SFT Framework).* New York and Geneva: United Nations, UNCTAD.
UNCTAD. (2022). *Review of Maritime Transport.* New York and Paris: UN UNCTAD.
(2023, 07 4). Retrieved from Online Etymological Dictionary: https://www.etymonline.com/word/sustain#:~:text=going%2C%22%20from%20the%20stem%20of,%2D%20%22to%20stretch%22).
UNOSD. (2020). *2020-2021 Sustainable Development Transformation Forum: Building Back Better and Greener - Sustainable, Low-Carbon Industrialisation.*
United Nations, G. A. (2015). *A/RES/70/1 Transforming our World: the 2030 Agenda for Sustainable Development.*
UNWOMEN. (2014). *World Survey on the Role of Women in Development 2014: Gender Equality and Sustainable Develop,ment.*
IMO. (2023, 11 21). *Wing-in-Ground (WIG) craft*. Retrieved from IMO International Maritime Organization: https://www.imo.org/en/OurWork/Safety/Pages/WIG.aspx
HELCOM. (2023, 11 24). *OpenRisk Guideline for Pollution Response*. Retrieved from HELCOM: https://helcom.fi/wp-content/uploads/2019/08/OpenRisk-Guideline-for-pollution-response-at-sea.pdf
Farshid, A. S. (2006). Glean Lean: How to use Lean Approach in Service Industries. *Journal of Services Research, 6*, 191.
Vokurka, R. L. (2000). The Role of Just-in-Time in Supply Chain Management. *The International Journal of Logistics Management*.
Kato, I. S. (2011). *Toyota Kaizen Methods: Six Steps to Improvement.* Taylor & Francis Group.
Klaassen, G. A. (1991). Economics of sustainability or the sustainability of economics: Different paradigms. *Ecological Economics, 4*(2), 93-115.
UN. (1968). *1968 CDP Report, ECOSOC and GA resolutions.* United Nations.
UN. (2000). *Millenium Declaration.*
UN. (2023, 11 21). *The Sustainable Development Goals Report 2023*. Retrieved from United Nations: https://unstats.un.org/sdgs/report/2023/?_gl=1*yfi5y4*_ga*NTk1NjQzNDQ3LjE3MDA1NjQyODY.*_ga_TK9BQL5X7Z*MTcwMDU2NDI4NS4xLjAuMTcwMDU2NDI4NS4wLjAuMA..
UN. (1972). *Report of the United Nation Conference on the Human Environment.* New York: United Nations Publicatons.
UN. (1972). *United Nations*. Retrieved from United Nations Conference on the Human Environment, 5-16 June 1972, Stockholm: https://www.un.org/en/conferences/environment/stockholm1972
UN. (2016). *Sustainable Development Goals*. Retrieved from The Sustainable Development Agenda: https://www.un.org/sustainabledevelopment/development-agenda-retired/
UN. (2012, 07 27). Resolution 66/288. The future we want. *General Assembly*.
Cui, Y., & Cao Y, J. Y.-S. (2021). Determinant factors and business strategy in a sustainable business model: An explorative analysis for the promotion of solid waste recycling technolgoies. *Business Strategy and the Environment(31)*, 2533-2545.
Sousa-Zomer, T. &. (2018). Sustainable businessmodels as an innovation strategy in the water sector: An empirical investigation of a sustainable product-service system. *Journal of Cleaner Production*(171), S119-S129.

Funded by the
European Union

Joyce, A. &. (2016). The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production*(135), 1474-1486.

Hart S L, M. M. (2003). Creating sustainable value. *Academy of Management Perspectives, 17*(2), 56-67.

Saebi T, L. L. (2017). What drives business model adaption? The impact of opportunities, threats and strategic orientation. *Long Range Plan, 50*, 567-581.

Teece, D. (2010). Business models, business strategy and innovation. *Long Range Planning, 43*, 172-194.

Morris M, S. M. (2005). The enterpreneur's business model: Toward a unified perspective. *Journal of Business Research, 58*(6), 726-735.

Rachinger, M. R. (2019). Digitalization and its influence on business model innovation. *Jouran of Manufacturing Technology Management, 30*(8), 1143-1160.

Osterwalder, A. P. (2005). Clarifying business models: Origins, present and future of the conceot. *Communication of the Association for Information Systems, 16*, 1-25.

Parolin G, M. T. (2024). How technology assessment tools support sustainable innovation? A systematic literature review and synthesis. *Technovation, 129*.

de Almeida Biolchini, J. M. (2007). Scientific research ontology to support systematic review in software engineering. *Adv. Eng. Inf., 21*(2), 133-151.

Funded by the
European Union