Sustainable Logistics Services of Food Provisions on Merchant Ships

Potential for Reducing Environmental Damage

Marieta Stefanova

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Dedication

I would like to begin this book with an expression of deep gratitude to my family for their constant support throughout the creative process. I am incredibly grateful to my husband, Daniel Stefanov, whose invaluable help has played a crucial role in bringing this idea to fruition and making it a reality.

I thank all shipping companies and logistics service users who have actively participated in this research by sharing their valuable experiences and perspectives.

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About the Author

Marieta Stefanova, PhD, is an Associate Professor at Nikola Vaptsarov Naval Academy, Bulgaria, where she teaches bachelor's- and master's-level courses in logistics, quality management, safety, environmental and security management, and freight forwarding. She has more than twenty-five years of professional experience as a quality manager in food manufacturing plants.

Stefanova is actively involved in several professional organisations, including the Expert Council of the Center for Quality of Goods and Consumer Protection at the University of Economics—Varna, the Union of Scientists Bulgaria, and the IGWT International Association for Commodity Science and Technology. She is also a life member of the International Maritime Lecturers Association (IMLA) and holds associate membership in the Association of Economists and Managers of the Balkans (UdEkoM Balkan). Additionally, she is a member of WoodEMA, the International Association for Economics and Management in Wood Processing and Furniture Manufacturing. With more than fifty published articles in national and international scientific journals, her research interests focus on quality management, logistics, and food safety.

Preface

Considering the dynamically changing environment of modern logistics, there is a growing need to adapt it to new realities. By combining innovations in technology with the principles of sustainable management, logistics can fundamentally rethink approaches to ensuring food security and safety in maritime transport. As a strategic component of the global economy, the maritime sector performs a critical function of ensuring the uninterrupted movement of goods and resources along key naval routes.

The provision of food resources for vessel crews is an essential component of the organisation of life and work on board, directly affecting their health, performance, and psycho-physical well-being. The main challenges related to the supply and maintenance of a varied and nutritious diet stem from the specificity of the maritime environment, which is characterised by isolation, limited access to fresh foodstuffs, and the need for the prolonged storage of provisions under specific conditions. Unlike shore-based individuals who have continuous access to a variety of food sources through commercial outlets and catering facilities, crew members are dependent on pre-positioned supplies, which significantly narrows the options for a variety of dietary choices. This constrained environment necessitates special attention to provisioning planning, supply logistics, and onboard food resource management.

Long sea voyages, spanning weeks or even months, pose significant challenges to ensuring balanced nutrition. Stocks of fresh fruit, vegetables, and meat are quickly depleted, leading to shortages of vital nutrients and vitamins needed to maintain crew health and performance. Limited rest and mealtimes, combined with long working shifts, often force seafarers to consume fast and unhealthy foods, increasing the risk of unhealthy eating habits.

Along with limited access to a variety of products, storage space on board is limited, making it even more difficult to maintain food quality and freshness, especially during long passages or adverse weather conditions. The result is a uniform and unbalanced diet that can have a long-term negative impact on the physical and mental state of the crew.

Overcoming these challenges requires an innovative approach involving customised meal plans based on individual crew needs and preferences.

Objective:

The aim of this monograph is to conduct a comprehensive study, identification, and analysis of existing practices and opportunities for future development in the field of ship provisioning, with a focus on sustainable management. Achieving this goal involves a holistic approach to the assessment of current challenges, the

optimisation of logistics processes, and the integration of sustainability principles into supply systems.

Within this research, four main tasks are defined, each of which corresponds to a separate chapter of this monograph and contributes to the achievement of the set goal:

- Analysing the current state of supply management, applicable standards, and related challenges. This assignment corresponds to Chapter One, "Challenges in Provisioning". It discusses the main characteristics of the current food supply systems on board merchant ships, focusing on the main standards and regulatory requirements. Special attention is given to identifying the challenges that affect the sustainable management of these systems.
- Exploring approaches to cost optimisation and improving logistics processes for economic sustainability. This task is presented in Chapter Two, "Economic Sustainability Aspect". It analyses how to increase economic efficiency by optimising costs and improving logistics processes in food supply. On the basis of the data collected, models and strategies that can contribute to the sustainable economic development of supply activities are examined.
- Analysing the relationship between ESG principles and the sustainable management of food systems on board. This task is developed in Chapter Three, "Social Sustainability in Provisioning". The main focus is exploring sustainability's social dimension in the context of ESG (environmental, social, and governance) principles. It examines the role of sustainable sourcing practices in improving crews' social sustainability and enhancing customer satisfaction.
- Formulating recommendations for improving the supply system with a focus on reducing the environmental footprint and providing healthier and more diverse diets. This task is addressed in Chapter Four, "Environmental Sustainability Aspect". It focuses on developing practical recommendations for improving the supply system, with an emphasis on environmental sustainability. Guidelines are included to minimise the ecological footprint of supply processes and ensure healthy and diverse food on board.

Research Thesis

The thesis of this monograph is that the sustainable management of provisioning has the potential to optimise operational efficiency, reduce environmental impact, and improve working and living conditions for marine crews.

The proof of this thesis is based on an analysis of current practices that highlight the need for changes to existing systems to achieve more sustainable outcomes. The study of best practices and the implementation of ESG principles serve as a basis for formulating strategies to reduce environmental damage and

increase maritime operations' sustainability. Furthermore, exploring future development opportunities provides a basis for efficient and sustainable resource management on board merchant ships.

The implementation of these tasks creates an overall conceptual framework for the sustainable management of shipping food supply. The analyses and recommendations developed will contribute to implementing sustainable practices that combine economic efficiency, social responsibility, and environmental compliance, ensuring the long-term sustainability of maritime operations.

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Author

1. Challenges in Provisioning

Chapter One discusses various aspects of the logistics of food provisions for merchant ships, focusing on the contemporary challenges and specificities of supply processes. The need to provide a variety of products, deal with space constraints on board, and ensure food safety are analysed in detail. The main regulatory requirements set out in the Maritime Labour Convention (MLC), which govern minimum standards for the quality, quantity, and nutritional value of provisions, are examined. Particular attention is given to the challenges arising from the need for sustainable supply chain management, including risk management, supplier diversification, and the adoption of innovative technologies and best practices. The final part of this chapter presents a methodological overview of approaches to assessing environmental footprint, including life cycle analysis and the Balanced Scorecard. The importance of a tailored approach and the integration of sustainable practices to improve sourcing and crew conditions is highlighted. This chapter contributes to filling the gap in the academic literature on the logistics of marine ship provisioning. It corresponds to the set task of analysing the current state of provisioning management, covering the standards and challenges associated with this process.

1.1. Current Aspects of the Supply of Ship Provisions

The logistics of food provisions for merchant ships requires highly efficient management, conditioned by the numerous constraints and specificities of the maritime environment. The main problem stems from the need to adapt the supply chain to the complex and dynamic nature of the supply chain while ensuring a balance between various interdependent factors—operational efficiency, economic profitability, food quality, and the sustainability of logistics operations (Karakasnaki et al. 2023; Nikolopoulos and Boulougouris 2020; Lee et al. 2019).

The food supply chain for merchant ships typically requires a wide variety of products in small quantities due to low crew numbers, which should be stored on board in limited space, from fresh fruits and vegetables to frozen foods and spices (Lau and Yip 2017; Mercier et al. 2019; Lao et al. 2012).

The aforementioned constraints require the precise planning, effective management, and coordinated execution of logistics operations related to providing sea crews with food provisions (Baum-Talmor and Şahin 2024; Neumann et al. 2024). The complexity of these operations is increased by the need to procure various food items in limited quantities, making it difficult for specialist suppliers to achieve economic viability. Due to the lack of sufficient financial incentives, some providers refuse to provide part or all of their services or limit the range of products offered. This creates further bottlenecks in the supply chain and requires the search for alternative solutions, such as the diversification of suppliers, the application of contractual incentives, or the use of innovative storage and transport technologies to ensure timely and complete provision for crews.

Food provision must take into account specific requirements, such as the availability of foods for special diets, religious considerations, and allergies, to ensure

both the physical health and mental well-being of the crew (Hjarnoe and Leppin 2013, 2014a, 2014b; Zyriax et al. 2018). The aforementioned constraints necessitate the careful planning, management, and execution of logistics operations for the provisioning of food supplies for marine crews.

Due to the limited quantity and wide variety of food provisions in demand, providers often have difficulty finding an economically viable incentive to provide these services, creating potential risks in the timely and adequate supply of certain products. Providing provisions to merchant ships requires not only highly specialised logistics skills and the appropriate infrastructure to manage controlled storage conditions, such as frozen and chilled commodities (Behdani et al. 2019), but also the efficient synchronisation of supplies with ships' trade routes (Elmi et al. 2022). This synchronisation contributes to minimising logistics costs and preventing supply chain disruptions, given the dynamics of maritime operations and variables related to weather and port procedures.

An additional aspect to consider is that merchant ships are not cruise ships and often follow different routes and visit different ports (Dos Santos and Borenstein 2024), which may complicate supply optimisation and require the individualised sourcing of food and other provisions from various suppliers. At the same time, merchant ships are exposed to greater risks and constraints related to safety and regulations, which may require greater attention driven by differences in legislative requirements in different ports and destinations visited. The difference in crew size between merchant ships and cruise ships is also one important factor affecting the food supply chain (Di Vaio et al. 2021). Merchant ships typically have a much smaller crew compared to cruise ships, which have a significant number of passengers in addition to a large number of employees (Hein et al. 2024).

The logistics of food provisions for merchant ships requires the application of advanced technology and the establishment of adequate infrastructure, including food safety management systems, risk minimisation strategies, and supplier diversification. The application of an individualised approach to sourcing that takes into account the ethnic and cultural characteristics of crews has been found to have the potential to contribute to efficiency gains. The provision of nutritionally balanced meals has been shown to improve crew satisfaction, health, and performance, which can also have a direct impact on creating an optimal working environment on board.

1.2. Basic Requirements for Ship Provisions

The minimum requirements for the provision of food and the conditions for its service on board ships flying the flag of a Member State are regulated in detail in Standard A 3.2 of the Maritime Labour Convention 2006 (Howorth and Howorth 2010). The standard defines and introduces mandatory requirements, which are classified into two main groups and are aimed at ensuring adequate food quality and appropriate sanitary conditions in the preparation and serving of food.

The first set of requirements is related to the availability of sufficient food and drinking water. Under the Convention, each vessel must have sufficient supplies of food and water that are of the required quality and intended for human consumption and, therefore, meet the required food safety standards. The quantity and quality of drinking water and food should meet the needs of the crew, taking into account the

number of seafarers on board (Karkori 2024d), their religious and cultural customs (Inegol and Yildirim 2024), and the duration and nature of the voyage.

The second set of requirements relates to ensuring the nutritional content, nutritional value, quality, and diversity of food provisions. The food provided on board must contain the necessary nutrients and be suitably prepared and served to ensure the crew's healthy nutrition. The rules imposed through the A 3.2 standard are implemented to ensure that seagoing crews have access to food that is adequate and of the required quality and that will contribute to maintaining their health and performance during the voyage (Exarchopoulos et al. 2018; McConnell et al. 2011; Piniella et al. 2013; ICLG 2024). Although the Maritime Labour Convention aims to meet all international maritime labour standards, food-related issues require additional attention related to the implementation of sustainable practices (Kendall et al. 2024).

Maintaining the food supply chain is a dynamic, complex, and difficult process that is directly linked to food spoilage during storage (Stoyanova and Stavreva 2022; Pashova 2021; Stoykova et al. 2020). The process of food spoilage is determined by the interaction between internal and external factors. Some of the intrinsic factors influencing food are water activity, pH, salt content, sugar content, consistency, and other intrinsic properties (Lisboa et al. 2024). Among the most significant extrinsic factors are usually temperature and moisture during transportation, storage, and handling, which can positively influence slowing the rate of spoilage and inedibility (Arsyad et al. 2021; Aung and Chang 2014; Flanagan et al. 2019). Salting, sugar treatment, and marinating are common approaches to extend shelf life, thereby more easily controlling factors that favour changes in the structure and sensory characteristics of food. The life cycle of provisions under abrupt changes in transport, storage, and handling conditions in environmental conditions can contribute to accelerating the spoilage process. The factors listed above make it necessary to design short and fast supply chains and to eliminate all unnecessary handling operations, which are not always possible due to long journeys or unsuitable handling conditions, in order to preserve inherent characteristics. The supply chain for food provisions is characterised by specific parameters that require precise management to ensure their reliability, safety, and compliance with regulatory quality requirements. To minimise the risk of deterioration in freshness and quality characteristics, science-based safety management approaches tailored to the specific storage conditions and specific logistics operations of the supply chain are necessary (Wei et al. 2024; Cvelihárová and Pauliková 2021; Marinova 2022; Arevalo Guillen and Canales Supanta 2023). The food supply chain must adhere to stringent safety and hygiene standards (Capunzo et al. 2005) set by regulatory bodies such as the Maritime Labour Convention and adopted Codex Alimentarius regulations based on HACCP principles (Karkori 2024c; Grappasonni et al. 2018). Food safety has been found to be one of the most important aspects of food supply management (Stevens and Parsons 2002; Scuri et al. 2019). According to the study by Karkori (Karkori 2024a), the main causes of foodborne infections on ships are contaminated raw materials, inadequate temperature control, inadequate heat treatment, the inadequate personal hygiene of service personnel involved in food preparation, and the use of contaminated water.

In addition to the introduction of a food safety system to maintain security during delivery, measures should be put in place to continuously monitor transport, storage, and preparation conditions on the basis of risk analysis. In view of the length of transport under different climatic conditions, it is important to use specialised transport and cold storage in the logistics chain to maintain optimum conditions for preserving their organoleptic characteristics and safety. According to many scientific studies, one of the most important conditions for maintaining food safety is the implementation of training the personnel involved in handling food products throughout the supply chain until the delivery of the prepared food to the crew itself (Sharif et al. 2024; Budiman et al. 2024; Sehgal et al. 2024; Rassia and Tsikis 2024).

According to Bolton, given the high costs and potential losses in the food supply chain, it is essential to implement effective cost management and supply optimisation strategies (Bolton 2024). Good practices for process improvement, according to Cooper, include the implementation of supplier management and selection programmes, procedures for negotiating better prices, and the implementation of tracking and inventory management technologies (Cooper 2024). Examples of improvements in the food supply chain include the use of advanced freight tracking technologies, such as RFID chips or inventory management systems, to control inventory better and minimise waste. Improving supplier selection processes and setting clear criteria, including indicators for the quality of provisions, can contribute to improving the reliability and safety of the food offered on ships.

Despite the requirements imposed by standards, in practice, a number of significant limitations have been identified in the feeding of seagoing crews, the main one being the lack of self-determination in the choice of food. The limitations are inconsistent with the diversity of food preferences and habits of crew members, who differ in ethnic background and cultural perceptions, with menus often in complete conflict with religious beliefs and traditions. The Şenbursa study states that there is an established practice of providing higher-quality and more varied food items for officers, while other crew members are limited to provisions of lower quality and variety, highlighting the need to develop more equitable and tailored food policies for all crew members (Şenbursa 2024). These constraints make it difficult to adapt diets to work and rest conditions, which often include irregular meal intervals due to the shifting nature of work and limited opportunities for physical activity during free time (Nittari et al. 2024).

Due to long periods of time on board, where seafarers are often exposed to stressful situations (Hystad and Eid 2016; Wadsworth et al. 2006; Mednikarov et al. 2019b) and external factors such as unpredictable weather and restrictions on access to land (Jegaden et al. 2019), food appears to be an important factor in their health (Dohrmann and Leppin 2017). Furthermore, the requirement for menu diversity is also necessitated by the diversity in cultural and religious perceptions determining preferences and providing the necessary nutrients and energy for seafarers who are exposed to physical and mental stresses during long periods of time on board (Karkori 2024b; Simons 2024). One of the important advantages of sustainable provisioning logistics is its ability to improve workflow and cover various aspects, including crews' purchase of food, beverages, medicines, protective clothing, equipment, and other necessary materials. Marine ship crews are exposed to harsh

conditions and rigorous work schedules, which creates conditions for focusing, with extreme attention, on the process of providing food provisions for an appropriate, balanced diet that meets energy and nutritional needs (Nam et al. 2024). At the same time, being able to provide a variety of healthy food can positively affect the psychological and physical well-being of crews and improve their work capacity and productivity (Mednikarov et al. 2019a).

Many scientific studies support the view that healthy food helps maintain the physical fitness and health of crews and has a direct impact on their ability to perform their job duties (Oldenburg et al. 2010; Nam et al. 2024; Bridger and Bennett 2011) and cope with the physical challenges of the sea.

Provisions must be checked for compliance, quality (including safety), and integrity before being accepted on board. Checks must be carried out not only on the quantity of goods by type and nomenclature but also on any damage or defects and the adequate verification of compliance with regulatory requirements, including temperature control (Hari Haran et al. 2024; Mollaoglu et al. 2024). A subsequent stage of the process is the storage and proper distribution of provisions over time until the next scheduled request. Storage should be carried out in a way that ensures their optimal condition and makes them easily accessible to the crew.

Optimising the supply and consumption processes of provisions requires the application of strict inventory management controls. The process requires the implementation of appropriate actions to prevent shortages or overstocking, as well as the timely removal of provisions that have spoiled or are past their minimum shelf life or expiry date due to various factors. In addition, the effective management of provisioning supplies includes a systematic approach to managing the waste generated from food consumption (Manzoor et al. 2024; Özkaynak and İçemer 2024). The effective management of waste streams on board is not only subject to legislative regulation in aspects such as the separate collection, transportation, and safe disposal of waste but is also imperative due to the need to minimise the amount of waste generated. In view of space constraints on board, this process requires the application of approaches such as recycling and alternative handling methods that contribute to optimal resource management and a reduction in environmental impact.

At the heart of improvements in food supply are advanced technologies and logistics networks that support continuous storage and transportation under controlled conditions and training programmes for food handlers throughout the supply chain. The qualification of personnel, combined with the introduction of clear regulatory requirements and detailed delivery procedures, is essential to ensure the quality and safety of food provisions on board merchant ships. Improving the security and reliability of supply chains requires a coordinated effort between shipping companies, distributors, specialist training institutions, and regulatory authorities. Effective controls in various stages of the process—by suppliers, crew, and supervisors—are conducive to minimising risks and maintaining high standards in supply.

Although effective provisioning supply management can have many positive aspects, certain risks and challenges need to be considered when planning and implementing processes. The intensive development of the modern global economy, coupled with the increasing impact of climate change, requires the introduction

of new standards and approaches for sustainability in marine provisioning logistics. (Lau and Yip 2017; Wang et al. 2020). These factors necessitate supply chain adaptation towards environmentally responsible practices, efficient resource management, and carbon footprint reduction to ensure the long-term sustainability and reliability of supply in the maritime environment. The integration of innovations with risk management strategies enhances the stability and resilience of supply systems, even in the presence of unforeseen events such as pandemics or disruptions caused by extreme weather conditions (Andersson et al. 2016).

The provisioning system performs an indispensable and strategically important function in maintaining the operational effectiveness and continuity of maritime operations, especially during extended voyages and long periods at sea. Ensuring an adequate quantity and variety of food items is critical to maintaining crew health, performance, and well-being while contributing to the successful accomplishment of assigned tasks in the complex maritime environment (Oldenburg et al. 2013).

Designing and managing logistics adequate for the conditions is challenging as the return flows are often distributed and, therefore, not cost-effective. It is good practice to introduce mathematical models to achieve economies of scale in the planning of reverse material flows. Applying such models could help make more optimal decisions in reducing total costs, workload variance, and total environmental emissions.

1.3. The Concept of Sustainability in Food Provisioning in the Context of the UN Sustainable Development Goals

The concept of sustainability originated in 1987 when the report Our Common Future (Brundtland 1989) was presented at the global level, laying the theoretical foundations for the modern understanding of sustainable development. The document was prepared and subsequently published by the World Commission on Environment and Development, known as the 'Brundtland Commission'—named in honour of its chairman, Gro Harlem Brundtland (Kono 2023).

This report highlights the serious threat to natural resources, pointing out that significant, unforeseen changes are occurring in the atmosphere, soils, water, flora, and fauna, and focuses on the fact that there are certain thresholds that cannot be crossed without threatening the overall sustainability of the ecosystem (Borowy 2013; Pearce and Atkinson 1998). A definition of sustainable development has also been formulated, which states that it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Borowy 2013).

Another important document characterising the principles of sustainability is the United Nations Framework Convention on Climate Change (UNFCCC), in force since 21 March 1994, which is an international treaty created after its signing in 1992 (UNFCCC 2008), and, to date, this Convention has participation from almost all countries in the world (Kuyper et al. 2018). The main objective of the UNFCCC is to prevent "dangerous" human interference with the climate system (Lefstad and Paavola 2024). Although the scientific evidence on climate change was limited at the time of its creation, the Convention is focused on protecting the interests of people and taking the necessary steps to address this challenge (Hermwille et al. 2017). The

Convention encourages States to take the first steps in addressing climate change by supporting and promoting efforts to reduce greenhouse gas emissions and adapt to its effects. The UNFCCC acts as a major catalyst for global efforts to combat climate change and achieve sustainable development, emphasising the need for cooperation and solidarity among all countries of the world.

Another major international climate change document is the Kyoto Protocol, adopted in 1997 in Japan (Sneddon et al. 2006). The Protocol can be characterised as a supplement to the United Nations Framework Convention on Climate Change (UNFCCC). The Kyoto Protocol was the first document to establish legally binding targets for greenhouse gas emissions, which are the primary cause of global warming (Rosen 2015). It establishes obligations for industrialised countries to reduce these emissions, setting specific targets for them over a period of time. The Protocol is a significant step forward in efforts to combat climate change and achieve sustainable development. Not only does it call for reductions in greenhouse gas emissions, but it has also sparked discussions and research in the logistics and supply chain fields, seeking to achieve more sustainable practices and more efficient resource management (Dogan 2024). The Kyoto Protocol is an integral part of the scientific debate and research on sustainability in food supply logistics, inspiring and supporting the search for scientific solutions to the world's challenges today.

The concept of sustainability is also directly linked to another international agreement, the 2015 Paris Protocol (Klein et al. 2017). The Paris Protocol is the result of efforts by world leaders to unite and cooperate to combat global warming and the negative effects it brings (Oberthür and Groen 2018). The aim of introducing the Protocol is to reduce global warming and limit the increase in the average temperature of the planet to less than 2 degrees Celsius compared to pre-industrial changes (Dimitrov 2016) in the context of logistics and supply chains. The Paris Protocol necessitates changes in transport processes through the promotion and development of more efficient and sustainable methods of food delivery and supply.

The United Nations (UN) has played a leading role in promoting sustainability globally, addressing key challenges such as poverty, inequality, and climate change (United Nations 2024; Mollaoglu et al. 2024; Biermann et al. 2017). In 2015, after much debate and discussion, a 2030 Agenda for Sustainable Development, known as the UN Sustainable Development Goals—SDGs 2030, was adopted (Biermann et al. 2017; Costanza et al. 2016). There are 17 UN Sustainable Development Goals (SDGs) in total and they cover the three main aspects of sustainability—economic, social, and environmental. These goals are interlinked, each contributing to sustainable development on a global scale.

The SDG integration matrix (Table 1) illustrates how the logistics of food provisions for merchant ships can support the achievement of specific objectives. This approach is built on the core principles of ESG (environmental and social responsibility and corporate governance), focusing on sustainable resource management and reducing negative environmental impacts. The matrix explores opportunities to optimise supply chains, increase efficiency, reduce environmental footprint, and achieve social responsibility in resource management, ensuring a better quality of life for crews and the sustainable management of marine resources.

The presented matrix (Table 1) summarises the options for integrating the UN Sustainable Development Goals into the logistics of food provisions for merchant ships, focusing on the application of ESG principles. The table presents how sustainable supply chain management can contribute to increasing efficiency, minimising environmental footprint, and strengthening social responsibility in the maritime sector. The synergy between sustainability objectives and logistics process optimisation highlights the strategic importance of the maritime sector in global sustainability efforts, offering practical solutions to overcome economic, social, and environmental challenges.

Influenced by the adoption of the United Nations Sustainable Development Goals, the International Maritime Organization (IMO) introduced regulatory mechanisms such as the Ship Energy Efficiency Management Plan (SEEMP) and the requirement to calculate the annual operational coefficient of energy efficiency (CII), which changed environmental standards in international shipping (Bayraktar and Yuksel 2023). Procedures for monitoring, reporting, and verifying the sulphur content of fuels and requirements for calculating the Energy Efficiency Design Index (EEDI) for ships have been introduced since 1 April 2022 (Dewan and Godina 2023). These initiatives complement sustainability efforts aimed at reducing the sector's carbon footprint and improving energy efficiency (Soltani Motlagh et al. 2023). The newly introduced procedures aim to ensure compliance with fuel sulphur emission standards, which is an important step towards protecting the environment and human health. Ship energy efficiency management planning aims to encourage shipowners to take measures to improve the energy efficiency of their vessels and optimise their fuel consumption. As of 1 January 2023, it is now also mandatory for all ships to calculate a Vessel Performance Index and to start collecting annual carbon intensity index data, with the result of the annual performance index obtained from the calculations classified from A (best) to E (worst). (Bilgili and Ölçer 2024; Friedman 2024; Lee et al. 2019; Sahin 2024; Zulfiqar and Chang 2023).

Table 1. A matrix for integrating the UN Sustainable Development Goals into food provisioning logistics.

Goal Objective	Focus on Logistics of Food Provisions
Goal 1: Eradicating poverty. The goal focuses on eliminating poverty in all its forms and aspects.	- Improving the quality of food offered to crews by ensuring access to healthy and nutritious food products, including the provision of a greater variety of fresh fruit, vegetables, and protein-rich foods. - Optimising food provisioning processes to ensure the rhythmicity of supply and minimise disaster situations associated with unstable supply.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 2: End hunger, achieve food security and improved nutrition, promote sustainable agriculture. The aim is to ensure secure and sustainable access to food for all people.	- Increasing the variety, nutritional content, and quality of food for crews. - Supporting sustainable agricultural practices and production by encouraging the purchase of goods from certified producers with respect for environmental and social standards. - Building sustainable food supply systems to ensure the stability and continuity of supply to ships, thus ensuring food security for crews.
Goal 3: Good health and well-being. The aim is to promote the health, well-being, and good physical and mental health of all.	- Educating crews on healthy eating and physical activity maintenance that will contribute to improving their physical health and well-being. - Providing access to medical care and health care on board ships, including the availability of necessary medicines and medical equipment to manage various health problems. - Supporting the mental health of crews by providing appropriate recreational facilities on board ships and psychological support and counselling when needed. - Integrating a holistic approach to healthy living on board, including other aspects such as compliance with hygiene standards, regular medical check-ups, and protection against various health risks.
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	- The organisation of educational programmes and courses for ship crews to enable the acquisition of new skills and competencies. - Providing access to online educational resources and distance learning platforms to allow crews to train while on board the ship. - Creating a shipboard environment that encourages the exchange of knowledge and experience between crew members by organising educational activities and forums to discuss important topics. - Integrating educational aspects into crew training programmes on safety and sustainable working practices.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 5: Achieve gender equality and opportunities for all.	- Supporting and encouraging women to enter the professional field of logistics, including as crew members on merchant ships. - The requirement to develop and implement policies and practices that ensure gender equality, equal career opportunities, and fair pay for identical work. - Providing training and retraining programmes to assist women in acquiring the necessary skills and knowledge for successful careers on ships.
Goal 6: Ensure availability and sustainable management of water and sanitation for all. The aim is to ensure sustainable access to clean water and sanitation for all.	- Installing adequate fresh water storage and filtration systems on board ships to provide sufficient water for crews' drinking and culinary needs. - Developing efficient water management and recycling programmes on ships to reduce losses and optimise the use of water resources. - The construction of onboard sewage treatment facilities to ensure the safe and environmentally sound disposal of waste materials at sea. - Training crews in sustainable water resource management and sanitation issues and encourage their active participation in maintaining the cleanliness and safety of ships' water systems.
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all. This objective focuses efforts on increasing energy efficiency and promoting the use of renewable energy sources.	- Investing in advanced and sustainable energy technologies on board ships to reduce dependence on conventional energy sources such as high-carbon fuels. - Developing energy efficiency strategies for ships that include the optimisation of processes and devices used to produce and consume energy on board. - Training crews in energy efficiency and energy resource management methods to improve their awareness and participation in ship energy cost reduction programmes.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. The aim is to promote sound economic growth and decent work for all.	- Creating jobs for crew members by ensuring decent working conditions, adequate pay, and the protection of their rights. - Investing in crews' training and skill development to increase their productivity and competitiveness in the labour market. - Establishing policies and programmes for the social and economic inclusion of crews and providing opportunities for career development and professional advancement. - Developing business models and practices that promote sustainable economic growth in the maritime industry, taking into account the social, environmental, and economic aspects of this activity.
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and stimulate innovation. This objective focuses on building sustainable infrastructure and promoting innovation.	- Investing in developing and upgrading appropriate port infrastructure to ensure the efficient and unimpeded movement of provisions and other cargo to and from ships, thereby improving logistical efficiency and sustainability. - The use of new technologies and innovative methods for logistics process optimisation. - Establishing policies and programmes to promote sustainable industrialisation in the maritime domain by supporting projects and initiatives to introduce cleaner and more efficient technologies for food processing and production. - Developing and supporting public–private partnerships to finance and implement innovative projects in maritime logistics and provisioning.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 10: Reduce inequality. Smoothly reach and maintain income growth for the poorest 40% of the population by 2030—at a rate higher than the national average.	- Ensuring easier access to employment, fair pay, and working conditions. - The development of social programmes and policies to encourage the inclusion of all crew members in society and the economy, providing training and professional development opportunities. - Establishing marine infrastructure and industry development programmes that create new jobs and income opportunities for local communities, especially in poorer areas and countries. - Supporting economic and social initiatives to promote entrepreneurship among local communities that can contribute to reducing inequality and raising incomes.
Goal 11: Transform cities and towns into inclusive, safe, adaptable and resilient places to live. The objective focuses on the sustainable management of cities and human settlements.	- The development of infrastructure for the sustainable supply of food products to cities and towns, including the modernisation of ports and warehouses for the more efficient reception and distribution of goods. - Improving logistics processes and networks for the delivery of food provisions to ensure faster and more efficient access to food for all. - Integrating sustainable technologies and practices into logistics systems to reduce carbon dioxide emissions. - Establishing waste management and material recycling policies and programmes to support the sustainable use of resources and reduce environmental footprint. - The development of community initiatives for sustainable development that involve local communities in decision-making and the implementation of projects to improve quality of life in cities and towns.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 12: Ensure sustainable consumption and production patterns. The aim is to promote sustainable consumption and production.	- Researching and implementing sustainable methods of food supply and preparation that minimise adverse environmental and social impacts associated with agriculture and fisheries. - Raising awareness and educating crews on sustainable food consumption and production practices to reduce food waste and ensure the more efficient use of resources. - Developing policies and standards for sustainability in food supply chains that promote transparency, environmental responsibility, and social justice.
Goal 13: Take urgent action to combat climate change and its impacts. The objective focuses efforts on combating climate change and its consequences.	- Reducing greenhouse gas emissions from food delivery vehicles by applying more efficient and environmentally friendly technologies. - Changing food delivery and preparation methods to minimise carbon footprint, including promoting vegan and vegetarian options, as well as using energy-saving appliances. - Investing in research and innovation aimed at developing new technologies and methods for sustainable food production and consumption.
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. The aim is to protect marine resources.	- The implementation of sustainable methods and resource management by food providers, with a focus on the conservation of fish stocks and restoration of vulnerable marine ecosystems. - Developing and applying innovative technologies for recycling and the efficient management of waste from ships and maritime activities to reduce marine pollution. - Encouraging and supporting the establishment of marine protected areas and reserves where human activities are regulated and limited to preserve biodiversity and ecological sustainability. - Promoting the sustainable use of marine resources for food by encouraging responsible fishing and ensuring transparency in seafood supply chains.

Table 1. *Cont.*

Goal Objective	Focus on Logistics of Food Provisions
Goal 15: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.	- Supporting sustainable agriculture and fisheries by promoting the use of products produced according to sustainable and certified practices. - Implementing smart inventory and transport management systems to reduce food waste and optimise resource use. - Transitioning to eco-friendly food storage and preparation facilities that minimise carbon emissions and respect the environment. - Building effective recycling and waste management systems to reduce environmental impacts and conserve biodiversity.
Goal 16: Promote peaceful and inclusive societies for sustainable development, ensure access to justice for all and build effective, accountable and inclusive institutions at all levels. The aim is to promote justice.	- Guaranteeing equal access to food resources for all crew members, regardless of their social or economic status. - Ensuring an effective system of conflict resolution and respect for crew rights, including access to fair justice in the event of disputes or violations of their rights. - Establishing an institutional framework to ensure the responsible and inclusive management of food provision logistics for merchant ship crews, with a focus on equity and equality.
Goal 17: Strengthen the means of implementation and relaunch the global partnership for sustainable development. The aim is to foster global partnership and cooperation to achieve the 2030 goals.	- Establishing international cooperation between countries, maritime organisations, and companies to improve the logistics processes involved in supplying ships with necessary foodstuffs. - Establishing mechanisms for sharing best practices and experiences among the different players in the maritime industry, which would help to allocate resources efficiently and optimise the supply of provisions. - Supporting programmes and initiatives to train and develop sustainable methods of food provisioning logistics to be implemented by shipping companies globally.

Source: Author's compilation based on data from United Nations (2025) Sustainable Development Goals.

The changes to the IMO legislation are a response to growing environmental concerns and the need to create a more sustainable maritime space. These amendments

are expected to have a significant impact on the shipping industry by encouraging innovation in technology and energy efficiency practices. Although non-compliance with these newly introduced measures is, in most cases, an additional cost for shipowners, these costs are expected to be recovered in the long term through lower fuel costs and lower greenhouse gas emissions.

Legislative requirements and changes in recent years have necessitated the introduction of stringent CO_2 reduction measures and more efficient resource and waste management models (Di Vaio et al. 2018). Supply chain sustainability practices are examined in terms of the triple bottom line (TBL) framework, which distinguishes three dimensions of sustainability: economic, environmental, and social (Ozturkoglu et al. 2022). In order to implement and monitor more sustainable performance, logistics firms that load with provisions need to define a set of performance metrics that provide decision-makers with a transparent understanding of what is happening in the supply chain at the present moment and guide them towards optimal future actions.

The international agreements presented require that the food provisioning system also stands out in the context of sustainability and environmental responsibility. Effective resource management and the selection of sustainable materials and sourcing methods can contribute to the reduction in environmental harm and the creation of more environmentally conscious maritime operations related to food provisions (Nam et al. 2024; Oldenburg et al. 2013; Sage 2011).

Following the review of legislation related to sustainability in the logistics of food provisions for seagoing ships, the next aspect to consider is how to measure sustainability and the environmental footprint in this area.

1.4. Methods for Measuring Sustainability and Ecological Footprint

The environmental footprint of feeding ship crews is an important aspect of sustainability in the maritime industry, measuring the impact on natural resources through all stages of the process—from production and transportation to storage and food preparation. The European Environment Agency published its first European Maritime Transport Environmental Report in 2021 (European Maritime Safety Agency 2021), laying the foundations for an annual analysis of the environmental aspects of maritime transport, including the sustainability of logistics and supply chains. The assessment of the environmental footprint of food consumed on board ships depends on several factors, including the sources of food products (agriculture, fisheries, livestock), the resources used (water, land, energy), greenhouse gas emissions from production (CO_2, CH_4, N_2O), and the impact on biodiversity and ecosystems. An example of this is how the excessive use of fish in crews' menus can lead to overstretched fish stocks and a loss of biodiversity, highlighting the need for a sustainable approach to food selection. In addition, the transportation and storage of food on board significantly impact the ecological footprint, especially when long-haul fuels are used or when waste is mismanaged. Such factors, together with inefficient kitchen appliances and water wastage in food preparation and sanitation operations, increase energy costs and emissions. Applying energy-efficient technologies and sustainable practices, including assessment methods such as life cycle analysis, can optimise processes and minimise negative environmental impacts.

One of the widely used methods for assessing environmental footprint is the Life Cycle Assessment (LCA) method (Ding 2014). LCA is a systematic method for assessing the environmental impact of products or processes, through which all phases of the life cycle are analysed, from extraction and production through transportation and use to the final disposal of waste from the activity (Önal et al. 2021). For the application of LCA to the feeding of ships' crews, all phases in the life cycle of the food product—production, transportation, storage, preparation, consumption, and waste generation and disposal—should first be identified. In the second stage, the impact of each phase that could have a negative impact on the environment should be assessed, including the measurement of greenhouse gas emissions, resource consumption, and other impacts such as water or soil pollution. The third stage of the life cycle methodology is to analyse and quantify each of the impacts against their severity and significance. The final stage is to develop a plan to reduce the environmental footprint by implementing sustainable practices in the production, transportation, storage, and consumption of food.

GHG emission assessment is a well-established method for quantifying emissions associated with various activities, including food consumption. CO_2 calculators can accurately quantify the greenhouse gases generated by the consumption of certain food products. These data are useful for reducing emissions by choosing more sustainable food products or optimising the logistics of transporting provisions on board ships. The method for estimating carbon footprint is described in detail in the study by Pandey et al., who review current approaches for calculating and applying this indicator in different sectors (Pandey et al. 2011).

Various mobile phone apps are interesting and quickly applicable methods to calculate carbon footprint. One of the most used methods is integration with Apple with the "Live Green Carbon Tracker" app (Sullivan et al. 2016). The app is a tool through which the carbon footprint is calculated for users' daily activities (Pramanik et al. 2019). The main purpose of this tool is to provide information and incentivise consumers to reduce their carbon footprint by focusing on their diet and transportation. The carbon footprint is the total amount of greenhouse gases caused by certain activities or consumption of energy and resources (Chapman 2024).

The effective management of food provisions requires an integrated approach to sustainability assessment. The Sustainability Balanced Scorecard (SBSC) provides a proven tool for structuring and monitoring key activities related to reducing the environmental footprint (Chehimi and Naro 2024). The application of the SBSC allows for the systematic measurement and integration of sustainability metrics into logistics processes while providing transparency and the opportunity for optimisation (Hristov and Searcy 2024).

The Balanced Scorecard for Sustainability (SBSC) is a method that allows organisations to compare different aspects of sustainability, including environmental, social, and governance (ESG) principles (Gandini et al. 2024). Applying an appropriate method is important because ESG principles represent inherently diverse and often incomparable aspects of sustainability that are nonetheless critical to evaluating an organisation or activity. In the context of the rationale for applying the SBSC, it is essential to highlight that different aspects of ESG principles are measured and evaluated with various indicators and criteria. For example, indicators such as

carbon dioxide emissions or water consumption are used for environmental aspects, social programmes in place, discrimination, or gender equality for social aspects, and corporate governance or ethical standards for governance. Of course, the indicators are mostly indirectly linked to the achievement of sustainability, which makes the alignment between them very difficult.

The advantage of applying this method is that the SBSC allows organisations to select criteria and indicators relevant to their activities and objectives and compile a comprehensive assessment that covers all aspects of sustainability. Moreover, the method allows organisations to focus not just on one aspect of sustainability but also on their overall impact on society, the environment, and corporate governance. Therefore, the use of the SBSC is scientifically sound as this method allows organisations to compare virtually incomparable aspects of sustainability using different performance and sustainability indicators and enables a more objective and comprehensive assessment of their sustainability performance.

The SBSC provides a framework that allows organisations to integrate these different aspects of sustainability and assess them individually as well as as a whole. This allows organisations to measure their progress towards sustainability goals while providing a common benchmark for assessing essential activities and designing improvement strategies based on specific and measurable data.

The SBSC includes several pillars that assess different aspects of sustainability, including financial, customer, process, and learning and development perspectives. Under each of these perspectives, specific indicators are included that address the economic, social, and environmental sustainability of the logistics of food shipping provisions. For example, from the financial perspective, the SBSC may include indicators such as the profitability of a sustainable food provisioning supply chain and cash flow management. Social sustainability can be assessed through indicators such as social customer satisfaction and food provisioning safety. Environmental sustainability includes indicators such as environmental investments and energy efficiency.

A Balanced Scorecard allows corporations and organisations in the marine food provisioning logistics industry to measure and monitor their sustainability efforts in terms of finance, customers, processes, and development and identify areas to focus on for improvement.

1.5. The Conclusion from Chapter One

On the basis of the analysis carried out in Chapter One, conclusions can be drawn about the complexity and multi-layered nature of the process of procuring food provisions for merchant ships. Space constraints on board, the need to provide a variety of food products, and the multicultural composition of crews create many challenges for logistics systems. At the same time, international regulatory frameworks, such as those set out in the Maritime Labour Convention, set standards for the safety, quality, and nutritional content of provisions. The conclusion from the aspects discussed is that sustainable supply chain management is critical to addressing environmental, social, and economic constraints. The application of scientifically based methodologies, such as Life Cycle Analysis and the Balanced Scorecard for Sustainability, allows for process optimisation, reduced environmental

footprint, and improved social responsibility. The individualisation of sourcing, which takes into account the cultural and dietary preferences of crews, is identified as an essential factor in increasing crew satisfaction and efficiency.

This chapter demonstrates the need for strategic approaches that combine regulatory requirements with innovations in management and technology. These approaches need to address the long-term sustainability and efficiency of supply chains, taking into account the specificities and dynamics of the maritime industry.

2. Economic Sustainability Aspect

Chapter Two focuses on the economic sustainability of food provisioning, with the main objective of exploring approaches to optimising costs and increasing the efficiency of logistics processes. Methods of cost reduction, appropriate pricing, and negotiation with suppliers are explored, as well as the importance of complying with legislative regulations and maintaining business integrity. Risk management is analysed with a focus on protecting against unforeseen events and minimising financial losses through the effective negotiation and control of contract terms.

Inventory and supply management practices are presented, with an emphasis on the optimal use of space in storage and transportation. Additionally, the benefits of employee training and investment in innovations that improve the sustainability and competitiveness of supply processes are explored. This chapter presents a study evaluating the effectiveness of current practices in the maritime industry and proposes specific solutions to improve economic sustainability. It is concluded that the systematic management of logistics operations can lead to significant economic benefits, an increased quality of supply, and improved working conditions for crews.

2.1. A Study on the Economic Sustainability of Shipping Provisions

This study on the economic sustainability of food provisioning was carried out with a focus on efficiency and process optimisation by exploring and analysing the opinions and experiences of professionals directly involved in the management of these supplies. The individuals studied included managers of logistics organisations, executives of companies in the food industry, procurement specialists, financial analysts, and employees responsible for inventory and supply management.

This study is based on the evaluation of existing sourcing methods and strategies, and it considers various aspects of logistics processes, compliance with legislative requirements, risk management, and financial analysis. The main objective of the study is to investigate and evaluate the efficiency and optimisation of the supply of food provisions in the marine industry. At the core of the study is the thesis that the improved management of these processes can significantly increase the efficiency and economy of maritime operations.

The thesis of this study is that there is a statistically significant correlation between the efficiency of logistics processes in the supply of food provisions and the economic sustainability of the maritime sector. Improvements in the management of these processes can lead to cost reductions, improved service quality, and increased crew satisfaction. This highlights how optimising the supply of food provisions not only improves economic efficiency but also enhances social sustainability and the overall productivity of maritime operations.

Null Hypothesis (H_0): The null hypothesis is that there is no statistically significant correlation between the efficiency of logistics processes in food provisioning and the economic sustainability of the maritime sector. This implies that the optimisation of procurement does not lead to cost reduction, an improvement in service quality, or an increase in crew satisfaction at the alpha = 0.05 level of significance.

Acceptable Hypothesis (H_1): The acceptable hypothesis is that there is a statistically significant correlation between the efficiency of logistics processes in the delivery of provisions and the economic sustainability of the maritime sector. This is expressed by a significance (p-value) of less than 0.05, indicating a strong correlation between the optimisation of supply processes and cost reduction, improved service quality, and increased crew satisfaction.

The hypothesis supports the assertion that sustainable food provisioning supply management can lead to significant economic benefits while improving the work environment and crew performance.

2.1.1. Data Collection Methodology

A combination of methods, including questionnaires and interviews with marine industry experts, crew members, and decision-makers involved in the procurement of food provisions, was applied to collect data. This approach is in line with the view of Slattery et al., who stress the importance of combined methods to collect data that are reliable and heterogeneous in nature (Slattery et al. 2011).

2.1.2. Participants in the Study

This study involved a survey of 98 respondents, selected from individuals directly involved or professionally interested in the management of food provisioning. The participants were managers and executives of logistics and food supply companies, owners and managers of food supply businesses, logistics and supply chain management specialists, financial analysts and consultants, and inventory and supply management personnel in food industry-related organisations.

Out of the 100 persons invited, 98 confirmed their participation, ensuring a high degree of representativeness in the survey. The participants represent a wide range of professionals with relevant experience and knowledge related to the efficiency and optimisation of food provisioning. The sample provides the necessary expert basis for the investigation and analysis of various aspects of provisioning logistics and contributes to the formation of sound scientific conclusions and recommendations. In order to protect their personal identity, all participants' personal data were removed from the questionnaires. Instead, each participant was assigned a unique code that identified them within this study but without revealing their identity. This approach ensured that the data were anonymous and could not be linked to specific individuals.

Prior to the start of this study, all participants were provided with comprehensive information about the objectives and methodology of the study and voluntarily confirmed their consent to participate.

2.1.3. Data Processing and Analysis Approach

According to Bryman and Bell, data aggregation is essential to ensure confidentiality while allowing for a comprehensive analysis of trends and patterns in a sample under study (Bell et al. 2022). Data analysis was performed by processing the information collected, and the data were processed in aggregate form to ensure that no individual identifiers were included. The questionnaire responses (Table 2)

were analysed to draw meaningful conclusions and identify key trends relating to the participants' perceptions of food provisioning.

Table 2. The questionnaire for the economic survey.

Possible Answers	Questions
☐ 1: Never or almost never ☐ 2: Rarely (less than once a year) ☐ 3: Moderately frequent (1–2 times per year) ☐ 4: Frequently (2–4 times per year) ☐ 5: Very often (more than 4 times per year)	Q1. How often are improvements made that would contribute to reducing operating costs in the delivery of food provisions?
☐ 1: Never or almost never ☐ 2: Rarely (less than once a year) ☐ 3: Moderately frequent (1–2 times per year) ☐ 4: Frequently (2–4 times per year) ☐ 5: Very often (more than 4 times per year)	Q2. How often do you encounter difficulties in complying with regulations in the marine industry, including sustainability related to the supply of provisions?
☐ 1: There is a serious shortage of stock management ☐ 2: Inventory management is inadequate ☐ 3: Inventory management enables business operations ☐ 4: Inventory management is appropriate for the purpose of the activity ☐ 5: Inventory management is very effective	Q3. How effectively do you think food provisions inventories are managed in the marine industry?
☐ 1: There is no such scheme ☐ 2: No scheme, but there are plans for the introduction ☐ 3: There is a scheme, but it is not adequate. ☐ 4: There is an adequate scheme. ☐ 5: There is an adequate scheme and staff are very happy with it.	Q4. Evaluate the extent to which the incentive scheme matches the qualifications of the staff involved in the supply of food provisions.

Table 2. *Cont.*

Possible Answers	Questions
☐ 1: Extremely high need for improvement (there is a serious need for reforms and improvements in risk and security management) ☐ 2: There is a great need (improvements in risk management and security are important and need to be undertaken as soon as possible) ☐ 3: There is little need for improvement (existing risk management and security procedures are acceptable, but there is room for improvement) ☐ 4: Minimal need for improvement (only some aspects of risk management and security need to be improved or reviewed) ☐ 5: No need for improvement (most aspects of risk and security management are considered adequate or relevant to the situation)	Q5. Assess the need for improved risk management and security in the supply of food provisions using the scale indicated

Source: Table by author.

Correlation analysis was selected as the main statistical method for establishing relationships between different aspects of respondents' perceptions, which is in line with the recommendations of Cohen et al., who highlight the importance of this method in analysing relationships between variables in research (Cohen et al. 2013).

The calculation of the Spearman correlation coefficient was performed using the XLSTAT software package (Addinsoft 2024). As Bogusławski et al. note, this coefficient is suitable for analysing data with ranks and nonparametric distributions, making it appropriate for the purposes of this study (Bogusławski et al. 2022). Furthermore, the method allows the identification of significant dependencies and trends associated with commodity supply processes with different quantitative and qualitative characteristics. Furthermore, as Ghauri and Grønhaug point out, qualitative data analysis encompasses not only the aggregation of the information collected but also its in-depth interpretation in order to draw meaningful and actionable conclusions. This approach provides a better understanding of phenomena under study and supports the formulation of effective solutions (Ghauri et al. 2020). This was applied in the present study, and the data were processed to extract trends and formulate recommendations for optimising logistics processes in food provisioning.

2.2. Analysis and Interpretation of Survey Results

2.2.1. Interpretation of the Mean Values Obtained from the Responses

After processing the collected information into an interpretable form, the main averages derived from the answers to the questions related to the frequency of improvements, difficulties in complying with regulations, the effectiveness of inventory management, the evaluation of incentive schemes, and the need for improved risk management were analysed.

Responses to the first question related to the frequency of improvements to reduce operating costs had a mean of 4.429. This result shows that the respondents believe that improvements are made frequently enough to contribute to reducing operating costs in food provision delivery. This suggests that there is an active effort towards optimisation and efficiency in this aspect of procurement, which is likely contributing to better resource management and cost reduction.

Responses to the second question related to difficulties in complying with regulations had a mean of 4.500, confirming that the respondents often face difficulties in complying with regulations in the marine industry related to the supply of food provisions. This highlights the need to improve processes and management systems to facilitate compliance with regulations and reduce associated difficulties.

Responses to the third question related to the effectiveness of food inventory management had a mean of 4.531. This result shows that the respondents consider stock management quite effective. The high score here points to well-established inventory management procedures and systems that are likely contributing to minimising wastage and ensuring adequate inventories on board.

Responses to the fourth question related to the evaluation of the motivation scheme had a mean of 4.102 and indicated that the respondents consider the motivation scheme to be satisfactory, but there is still room for improvement. This suggests that although the motivational measures are effective to some extent, there is room for improvement in order to increase staff satisfaction and motivation.

Responses to the fifth question related to the need for improved risk management and security took an average value of 4.398. This result indicates that the respondents see a significant need for improvement in risk management and security in the delivery of food provisions. This underscores the importance of implementing better risk management systems and practices to ensure the safety and efficiency of procurement.

2.2.2. Interpretation of the Correlation Matrix

The analysis was carried out with a focus on the relationships between different aspects of food provisioning, based on the results of the respondent's answers to the correlation matrix, and interpreted their relevance to logistics processes. The frequency of improvements to reduce operational costs and the need for the improved management of onboard food provisioning is presented in Table 3.

Table 3. Correlation matrix.

Variables	Q1	Q2	Q3	Q4	Q5	3	4	5
Q1	1	0.564	0.557	0.639	0.937	−0.564	−0.576	0.881
Q2	0.564	1	0.960	0.538	0.619	−0.427	−0.320	0.552
Q3	0.557	0.960	1	0.553	0.615	−0.443	−0.297	0.538
Q4	0.639	0.538	0.553	1	0.709	−0.569	−0.279	0.589
Q5	0.937	0.619	0.615	0.709	1	−0.657	−0.554	0.911
3	−0.564	−0.427	−0.443	−0.569	−0.657	1	−0.264	−0.286
4	−0.576	−0.320	−0.297	−0.279	−0.554	−0.264	1	−0.849
5	0.881	0.552	0.538	0.589	0.911	−0.286	−0.849	1

Source: Table by author.

A strong positive correlation (0.937) was found between the frequency of improvements implemented and the need for enhanced risk and security management. The data show that as the number of measures implemented to reduce operational costs increases, so does the need to improve risk management and safety mechanisms. This can be explained by the fact that innovations often require additional actions to minimise possible risks and ensure the effectiveness of their implementation.

After analysing the data obtained in the matrix, an average positive correlation (0.619) was found between the difficulty in meeting regulatory requirements and the need for improvement in risk and security management. The results suggest that as the difficulty in complying with regulations increases, so does the need for more effective governance mechanisms. This underscores the importance of developing streamlined systems and procedures to reduce operational risks and facilitate regulatory compliance.

On average, a strong positive correlation was found (0.557) between the effectiveness of inventory management and the frequency of improvements made, indicating that when improvements are made more frequently, inventory management is more effective. This suggests that improvements in processes and systems lead to better inventory management, which can improve supply efficiency and reduce wastage.

The strong positive correlation (0.709) between incentive scheme scores and the need for improved risk and security management indicates that the better the incentive scheme matches staff qualifications, the greater the need for improved risk and security management is. This can be interpreted as a signal that motivated and qualified staff are more aware of and require better risk and security management measures in order to operate effectively.

The negative correlation (−0.657) between the need for improved risk and security management and the frequency of regulatory difficulties highlights that when risk and security management are improved, regulatory compliance difficulties decrease. This indicates that better risk and security management facilitates regulatory compliance, leading to a smoother delivery process.

The results obtained from the correlation matrix reveal that despite the positive results in the area of inventory management and the frequency of cost reduction improvements, there are still significant challenges related to regulatory compliance and risk and security management. The high scores for these aspects indicate that

while current practices are effective to some extent, there is significant room for improvement that could lead to better process optimisation.

The correlation matrix reveals significant relationships between different aspects of the respondents' perceptions of food provisioning. The strong positive correlations highlight the correlation between the frequency of improvements made, the effectiveness of stock management and motivational schemes, and the need for improved risk and security management. Negative correlations, on the other hand, indicate that improvements in risk and security management can facilitate compliance with regulations and reduce difficulties in this aspect. These results provide important pointers for future strategies and initiatives aimed at optimising processes and improving efficiency and safety in the maritime industry, which we will address in the next section by compiling a Balanced Scorecard.

2.2.3. Factor Analysis and Interpretation of p Vectors

A factor analysis of the influence of the different components on the variables under study was conducted, revealing how these factors contribute to understanding the underlying processes and issues. The figure of p vectors (Figure 1) presents the results of the factor analysis, which reveals the main components ($p1$, $p2$, $p3$, $p4$) and their impact on the different variables. The analysis of these components provides a deeper understanding of the factors that influence different aspects of perceptions of food provisions on board ships.

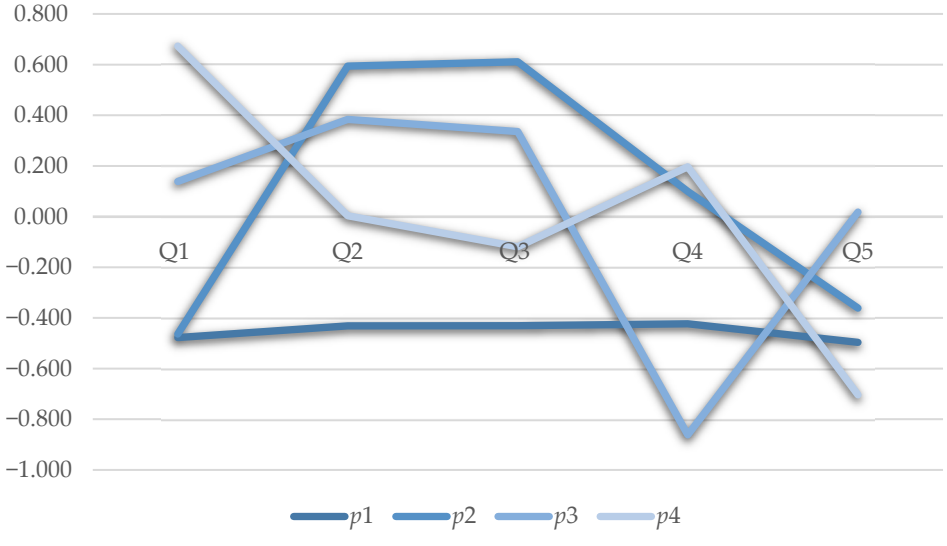


Figure 1. Factor analysis vectors. Source: Figure by author.

The first variable, which examines the frequency of improvements to reduce operating costs, shows a strong positive correlation with the fourth factor (0.673). This implies that the $p4$ factor plays a significant role in driving improvements that reduce operating costs. The negative correlations with $p1$ and $p2$ (-0.477 and -0.464)

suggest that these factors have an opposite effect, which may indicate possible barriers or constraints associated with these aspects.

The second variable related to difficulty in complying with regulations has a strong positive correlation with the second factor (0.594). This highlights the importance of $p2$ as a major factor related to regulatory challenges. Also, the significant correlation with $p3$ (0.384) indicates that this factor also has an influence on regulatory compliance difficulties. The positive correlation with $p4$ is minimal (0.003), indicating that this factor does not play a significant role in this context.

The third variable, which assesses the effectiveness of food inventory management, shows the strongest positive correlation with the second factor (0.611). This suggests that $p2$ has a major influence on effective inventory management. The positive correlation with $p3$ (0.335) is also significant, while the negative correlations with $p1$ and $p4$ (-0.431 and -0.120) indicate the presence of factors that may hinder efficiency.

The fourth variable, assessing motivational schema, has the strongest negative correlation with the third factor (-0.861). This means that $p3$ has a significant negative impact on the motivational schema score. The positive correlation with $p4$ (0.197) and the negative correlation with $p1$ (-0.423) highlight the variety of influences that can affect staff motivation.

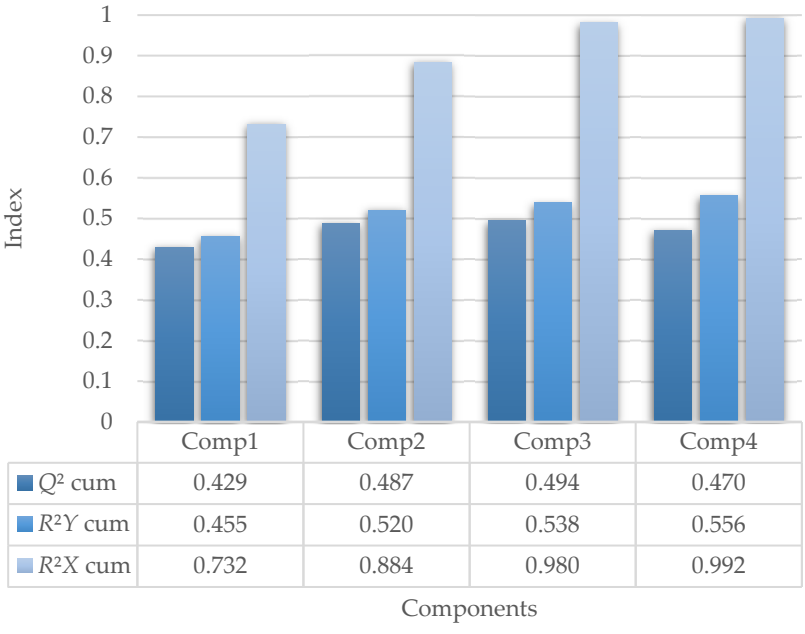
The fifth variable, assessing the need for improved risk management and security, has the strongest negative correlation with the fourth factor (-0.704). This suggests that $p4$ is a major factor in reducing the need for improvements in risk and security management. The negative correlations with $p1$ and $p2$ (-0.496 and -0.361) also show opposing influences, while the correlation with $p3$ (0.018) is minimal.

Interpretation of the p vectors reveals the important factors that influence different aspects of the delivery of food provisions on board ships. The strong positive and negative correlations highlight the importance of the different factors and their influence on the frequency of improvements, the difficulty of complying with regulations, the effectiveness of inventory management incentive schemes and the need for improved risk and security management. These results provide valuable guidance for developing strategies and initiatives to optimise and improve efficiency and safety in the maritime industry.

2.2.4. Model Quality Assessment

The model quality metrics figure presents the cumulative values of Q^2, R^2Y, and R^2X for the four components (Comp1, Comp2, Comp3, Comp4) (Figure 2). These statistics are relevant for assessing the interpretability and explanatory power of the model.

The cumulative values of Q^2 range between 0.429 and 0.494 and indicate that the model has good interpretability. The highest value for Comp3 (0.494) indicates that this component has the strongest interpretative power among the four components. This means that Comp3 can predict the variation in the dependent variables most accurately, which is key to the analysis.



	Comp1	Comp2	Comp3	Comp4
Q^2 cum	0.429	0.487	0.494	0.470
R^2Y cum	0.455	0.520	0.538	0.556
R^2X cum	0.732	0.884	0.980	0.992

Figure 2. Model quality by number of components. Source: Figure by author.

As for the cumulative values of R^2X, they indicate the strength of the model relative to the dependent variables. The values increase gradually from 0.455 for Comp1 to 0.556 for Comp4. The progression shows that with the addition of each successive component, the model explains an increasing proportion of the variance in the dependent variables. The highest value of R^2Y for Comp4 (0.556) indicates that the fourth component has the strongest explanatory power relative to the dependent variables.

The cumulative values of R^2Y, which range from 0.732 for Comp1 to 0.992 for Comp4, indicate the model's explanatory power relative to the independent variables. The high values demonstrate that the model explains almost all of the variation in the independent variables, which is an indicator of the model's high quality. The highest value for Comp4 (0.992) indicates that this component explains almost all of the variation in the independent variables, which is an extremely positive result.

An analysis of the model quality shows that all components have good interpretative and explanatory power. Particular attention should be paid to the third and fourth components, which demonstrate the highest values of Q^2 and R^2. The cumulative values of R^2Y for the four components indicate that the model explains almost all of the variance in the independent variables, which is an indication of high model quality. These results emphasise that the model is robust and provides useful information on the factors influencing perceptions of food provisions on board ships.

2.2.5. Key Lessons and Directions for Future Strategies

The survey of crew views on the supply of provisions on board ships provides valuable information on current perceptions and challenges associated with various aspects of the provisioning process. An analysis of the survey results, including

correlation and factor analysis, reveals the significant factors that influence the efficiency, safety, and management of stores. The results provide the basis for the development of the Balanced Scorecard (SBSC) for the economic sustainability of food provisioning. The SBSC is an appropriate tool that can integrate financial, user, process, and learning and development perspectives to provide a holistic approach to ship provisioning management.

2.3. The SBSC as a Strategic Framework for Economic Sustainability

The Balanced Scorecard (SBSC) compilation provides a structured framework for the sustainable management of ship provisioning by focusing on economic aspects organised into four perspectives: financial, user, process, and learning and development. Through it, a system integrating various indicators and action areas is compiled, aimed at optimising processes, minimising costs, and increasing efficiency while maintaining compliance with regulatory standards and best practices. Table 4 summarises the main perspectives and indicators, which will be analysed in detail in the following presentation. Each perspective includes specific areas such as cost optimisation, risk management, inventory efficiency, and professional training. This structure serves as a basis for developing strategies that aim not only at economic efficiency but also at the sustainability of supply in view of the specific needs of the maritime industry.

Table 4. Balanced Scorecard (SBSC) for economic sustainability of food provisions.

2.3.1. Financial Perspective	**2.3.2. User Perspective**	**2.3.3. Process Perspective**	**2.3.4. Training and Development Perspective**
- Process and cost ptimisation - Compliance with regulatory requirements and standards - Risk management and secure shipping with provision disruptions and force majeure	- Market competitiveness and long-term stability - Minimising the risk of supply chain disruption - Managing operational risks, unforeseen incidents, or losses	- Effective inventory management, including planning and turnover - Effective management of onboard provision supplies - Optimisation of order management and provisioning - Analysis of risks and opportunities for optimisation	- Professional training for process optimisation - Interdisciplinary approach and collaboration - Introducing technological innovation in supply

Source: Table by author.

Section 2.3 presents an analytical framework for understanding the complexity of the economic processes involved in ship provisioning, with an emphasis on optimisation methods applicable to each specific aspect of the processes.

2.3.1. Financial Perspective

- The first aspect relates to process and cost optimisation.

Transporting and storing provisions on board ships requires precise planning and effective management to ensure the safety of the goods and crew. A key aspect of this process is ensuring compatibility between different types of goods, as well as their rational distribution in storage spaces (Lee and Song 2015). In addition, maintaining optimal storage and transportation conditions is essential to prevent contamination, damage, and disruption to the quality of goods (Hassan and Osman 2024). As part of supply chain management, the effective monitoring of storage and transportation also plays an important role in maintaining the long-term safety and quality of supply (Jasmi and Fernando 2018).

Reducing wastage and spoilage is a major challenge in sourcing food provisions. This can be achieved through the use of specialised packaging that protects the goods during transport, as well as the application of technologies to control temperature and humidity conditions. Crew training in the proper handling and storage of goods further minimises the risk of damage or loss. Efficient cargo handling requires the use of appropriate loading and unloading equipment to increase productivity and reduce losses. The optimisation of routes and logistics chains also plays a significant role in reducing dwell times at ports and minimising the risk of delays.

Forecasting provisioning needs is critical to successful supply management. Analysing historical consumption data and demand trends provides the basis for accurate planning. Factors such as crew numbers, voyage duration, and seasonal variations must be taken into account to avoid shortages or surpluses of provisions. The optimisation process could also look towards the integration of advanced analytical tools and software platforms to facilitate decision-making and contribute to better resource management.

Optimising provisioning processes requires focusing efforts on several improvement perspectives that can increase process efficiency and sustainability.

First and foremost, data governance plays an essential role in improving processes. Historical supply and consumption data can be analysed to create accurate forecasts and supply plans.

Second, logistics process optimisation encompasses the development of efficient delivery routes to minimise transportation costs and time. Combining orders from the same supplier and implementing automated warehousing and distribution systems can lead to savings and more efficient management of logistics operations.

Third, long-term partnerships with suppliers have the potential to provide opportunities for improved terms and pricing. The use of contracts with clearly defined quality and performance requirements could provide greater predictability and process sustainability.

Fourth, the integration of advanced technologies such as the IoT, blockchain, and artificial intelligence can increase transparency and efficiency in the supply chain. Technology solutions such as specialised packaging and temperature control systems could help reduce the loss risk and ensure provision quality.

Fifth, dynamic inventory management provides significant opportunities for optimisation by minimising excess quantities and reducing scrap. By continuously

monitoring and analysing inventories, the optimal use of resources can be achieved while creating the conditions for the sustainable and efficient management of provisions.

Sixth, regulatory compliance represents an important opportunity for supply optimisation. Adapting to new safety standards and international norms provides opportunities to develop flexible and easy-to-implement procedures that not only ensure legal compliance but also improve operational efficiency in the delivery process.

Finally, risk management offers opportunities for optimisation by minimising potential losses. The identification of possible risks, combined with the implementation of force majeure response strategies, creates a basis for increasing process resilience and flexibility.

In recent years, there have been significant global challenges in supply chains caused by accessibility issues to logistics infrastructure (e.g., port closures, border controls, etc., in the wake of the pandemic) and labour shortages. These developments have created a need for logistics companies to accelerate the digitisation of logistics processes and business operations in order to adapt to changing market conditions and achieve greater flexibility and efficiency. The increase in digitalization and the need for more integrated and seamless collaboration across logistics, supply chains, inventory management, and manufacturing represent key trends in today's business world. Publications in scholarly journals confirm that the integration of technologies such as artificial intelligence, the Internet of Things, and blockchain provide significant opportunities for more efficient supply management (Rejeb et al. 2019; Hemamalini et al. 2024; Hartmann and De Grahl 2011).

It has been found that external factors can significantly influence the prediction of crew provisioning requirements. These factors include possible changes in ship itineraries, changes in regulations regarding food standards and safety requirements, the frequency of force majeure, and potential disasters specific to the region in which voyages are operated, which may affect the availability and accessibility of provisions. Including these external factors in analysis provides opportunities for managers to make more accurate forecasts of provisioning needs and prepare for potential changes in demand (Liu et al. 2024; Wan et al. 2019).

An applicable method to improve supply chain efficiency is supply chain integration, which improves communication, information sharing, and information resources between all actors. The exchange of data on inventories, current orders, and demand forecasts allows for faster responses to changes in demand and market conditions. In addition to information sharing, building long-term partnerships between actors in the chain is important. These partnerships can be based on mutual trust, cooperation, and the achievement of common goals and results. In order to improve integration between actors, information sharing should take place in real time. In this way, actors are able to work together to identify weaknesses in supply processes and implement appropriate strategies to improve them.

The presented examples show different approaches to the optimisation of the supply of provisions on board a ship. The choice of a method or a combination of methods can significantly influence the optimisation of the supply chain of provisions in order to save money and avoid unnecessary waste in their delivery.

- The second aspect relates to activities in compliance with regulatory requirements and standards.

The second aspect of economic sustainability focuses on integrating activities that meet stringent regulatory requirements and standards and ensure the safety, quality, and traceability of food products. International regulations cover fundamental areas such as hygiene, storage and transport conditions, and the control of product composition, and these regulatory frameworks create a solid foundation for the long-term financial sustainability of a business and the preservation of its reputation (Chavan et al. 2024). Ensuring compliance with these regulations not only protects businesses from risks but also provides significant opportunities for future innovation and strategic development.

First of all, food labelling is a fundamental element in ensuring compliance under this regulatory framework. The accurate provision of information on composition, shelf life, and storage conditions is essential to build consumer confidence and promote informed choice. In addition, the development of new labelling technologies, such as the implementation of innovative product scanning and tracking systems, opens up new opportunities to optimise supply chains and improve efficiency (Shin et al. 2024). These technological improvements not only provide a competitive advantage but also offer the potential to create sustainable business models that can meet the growing demands for safety and traceability in globalised markets.

Secondly, product traceability systems play a key role in ensuring transparency throughout the supply chain. They enable rapid responses to incidents and support risk management. Development opportunities include the digitisation of traceability through blockchain technologies and automated monitoring systems, which reduces operational costs and increases efficiency.

Third, compliance with regulatory standards minimises the risk of penalties and financial losses while building trust among customers. Implementing good business practices such as transparency, honesty, and accountability not only strengthens companies' reputations but also creates a foundation for sustainable partnerships. Improving internal procedures and regular audits can significantly improve efficiency and reduce the likelihood of misconduct.

Consumer preferences also open up new opportunities for development. Today's market increasingly demands products that not only meet high safety standards but are also produced and supplied in an ethical and sustainable way. Logistics companies can take advantage of this trend by introducing sustainable practices, such as using environmentally friendly packaging and transport methods and raising customer awareness of the ethicality of their products.

Last but not least, control and fraud prevention systems create additional security in the delivery process. The development of specific verification and traceability mechanisms, as well as the regular training of staff in ethical standards, supports the sustainable development of companies and strengthen customer confidence.

These development perspectives outline a clear development framework that integrates regulatory compliance, ethical standards, and sustainable practices, thereby contributing to economic sustainability and competitive advantage in the food industry.

- The third aspect of economic resilience in the context of the financial perspective relates to risk management and security in the delivery of provisions.

Effective risk management involves strategically anticipating potential threats and minimising possible negative supply chain implications. This includes both identifying supply vulnerabilities and ensuring transparency and resilience in the overall supply process, which is essential for the long-term stability of businesses (Aven 2015). Some studies have shown that an important element of maintaining competitiveness in the global economy is effective risk management, which requires not only responding to critical situations but also building prevention and monitoring systems that allow companies to adapt quickly to changes in market conditions (Choi 2020; Stoyanova et al. 2024, 2022). Good risk management in the maritime industry has been found to be critical in ensuring the security of supply and maintaining supply chain resilience, a necessity in the context of globalisation and the growing importance of logistics (Skipworth and Hoek 2019).

The continuous improvement of risk management strategies through innovation in data tracking and analysis technologies is not only a prerequisite for success but also an important factor in maintaining the long-term competitiveness of companies operating in the maritime industry (Tummala and Schoenherr 2011). Ensuring process stability and proactively managing risks play a critical role in improving financial performance and strengthening business resilience in uncertain environments.

Preventing supply disruptions in the first place requires long-term planning and risk monitoring. Developing forecasts of required resources and associated risks allows potential problems to be identified in advance and preventive measures put in place. The coordination of procurement schedules and rhythmic execution facilitate the early detection of anomalies that may signal violations or fraud. Technology solutions such as real-time tracking systems provide valuable information on the movement of goods and support timely decision-making.

Secondly, climate change poses a significant threat to the stability of supply chains. Natural disasters such as floods and droughts can disrupt supply, requiring the implementation of flexible and transparent supply chain management systems. The use of monitoring technologies, such as location sensors and cargo tracking, allows companies to adapt their logistics strategies in emergencies and minimise the impact on operations.

Thirdly, protection from cyber-attacks is an important aspect of modern logistics. The increasing number of cyber threats requires investment in secure IT systems and staff training. The integration of technologies such as blockchain can provide a higher level of security and transparency, reducing the risks of unauthorised access and fraud.

A focus on environmental, social, and governance (ESG) compliance also plays an important role in the sustainability of supply chains. Companies need to review their partnerships and implement sustainable standards to reduce carbon emissions and environmental footprint. Assessing suppliers' environmental performance and implementing sustainability programmes can improve environmental performance and meet the demands of today's market.

Finally, demographic changes and difficulties in attracting skilled labour create additional challenges. Companies can invest in education programmes, automation and innovation to attract and retain talent while increasing the efficiency of their operations.

Implementing comprehensive risk management, sustainability, and technological innovation strategies strengthens the security and efficiency of supply chains, contributing to the maritime industry's long-term financial stability and competitiveness.

2.3.2. Consumer Perspective

The first aspect of the consumer perspective relates to achieving market competitiveness and long-term stability through the integration of ESG principles and effective business relationship management. The implementation of sustainable practices, such as waste management, the use of green technologies, and energy efficiency optimisation, contribute to reducing costs, improving reputation, and increasing the attractiveness of investment for organisations. For example, investing in renewable energy not only reduces energy costs but also creates a competitive advantage by demonstrating environmental responsibility.

First and foremost, sustainable data management and the prevention of information leakage are essential to maintain customer trust. These encompass developing robust IT systems, implementing data protection policies, and conducting targeted staff training to mitigate cyber risks. Strengthening information security not only limits the potential for legal penalties and financial loss but also demonstrates organisations' commitment to ethical standards and sustainable business practices.

Secondly, protection from breaches of contracts is a key factor for business sustainability. Breaches can lead to significant legal and financial consequences, as well as loss of trust from customers and partners. Effective contract management involves the clear articulation of terms, rigorous monitoring of their enforcement, and establishment of mechanisms for open communication with customers and suppliers (Amoah and Nkosazana 2022; Rao et al. 2024; Sarder 2021; Strandhagen et al. 2017). This allows for the early identification of potential conflicts and prevention of breaches that may threaten business stability.

Third, the loss of supply chain partnerships poses a significant risk to business sustainability. Maintaining long-term partnerships requires clear and mutually beneficial contractual agreements, the regular monitoring of partners' activities, and adaptability to emerging risks. An integrated approach to risk management, combined with transparent communication, strengthens trust between supply chain participants and minimises the likelihood of losses or disruptions.

Fourthly, ESG principles are playing a positive role in responding to growing consumer demands for ethical and sustainable products. Logistics companies that implement sustainability standards and assess their suppliers' environmental performance can minimise adverse environmental impacts and build stronger customer relationships. This not only strengthens competitiveness in the market but also creates a foundation for long-term stability.

Integrating these approaches ensures organisations' economic sustainability and competitive advantage while strengthening the trust of customers, partners and society in their activities. Protecting against the loss of partnership agreements

throughout the supply chain requires an integrated approach that encompasses clear agreements, effective risk management, and open communication with all stakeholders. The approach would not only help to prevent supply chain losses and problems but also to maintain long-term partner relationships and business sustainability.

The second aspect of the consumer perspective relates to minimising the risk of supply chain disruptions, which is critical to achieving economic sustainability and operational reliability. In today's environment of global instability, the ability to manage supply chain risks is a key success factor for any organisation (Mobo et al. 2025; Galanakis 2024; Hine 2024; Nahavandi 2019). A key approach to risk mitigation is to create a diversified portfolio of suppliers and resources, which increases resilience in the face of financial or logistical disruptions.

Firstly, the regular monitoring of key metrics such as delivery time, the percentage of orders successfully fulfilled, and the number of delayed or diverted deliveries ensures the timely identification of potential problems. This also includes assessing the ability of suppliers to respond to crisis situations, which is particularly important in the maritime industry, where delays can have serious consequences.

Secondly, stock optimisation is an essential element to prevent outages. Rather than maintaining separate warehouses for different types of provisions, applying a common stock model allows better use of stock, minimising costs and ensuring uninterrupted supply. This approach requires integrated inventory management based on demand forecasting and the regular monitoring of stock levels.

Third, advanced technologies such as automated warehouse management systems, demand forecasting software, and real-time tracking technologies can be used to help optimise processes (Balan et al. 2024; Lopes et al. 2024; Tijan et al. 2019; Sira 2024). This could provide better visibility and agility, allowing the timely recognition of potential risks and taking preventive measures.

Fourth, building strong partnerships with suppliers can achieve greater supply chain security. Regular communication and data sharing with suppliers, including information on stock and demand forecasts, can contribute to preventing disruptions and optimising supply.

Fifth, implementing supply chain risk management procedures, including quality control, monitoring delivery times, and assessing the financial stability of suppliers, minimises the likelihood of serious breaches. An integrated approach that combines technology solutions and good business practices ensures greater supply chain resilience.

Last but not least, regular training can be conducted to help create a culture of awareness and preparedness for emergency response. Developing clear response procedures and forming rapid recovery teams could ensure that disruptions are dealt with effectively and minimise risk.

Implementing the strategies listed above would help minimise the risk of disruptions and strengthen supply chain resilience. By integrating innovative technologies, risk management, and robust partnerships, organisations can achieve greater reliability, reduced costs, and increased customer satisfaction.

The third aspect of the user perspective related to economic resilience is the management of operational risks, unforeseen incidents and losses.

The effective management of operational risks is an inherently strategic activity that aims to achieve sustainability in logistics operations. This requires developing integrated quality management, data protection and information security systems, and adaptive crisis plans to enable rapid response to emergencies. This approach minimises the likelihood of unforeseen losses and ensures the stability of operations.

First and foremost, monitoring financial and operational risks, as well as proactively managing regulatory, legislative, and market challenges, is essential to protect the reputation of firms and to adapt to the external environment. This includes regularly monitoring key indicators and putting in place measures to minimise their negative impact.

Secondly, the optimisation of pricing and supply cost management is a fundamental factor for competitiveness. The use of sophisticated technologies for warehouse and transport network management allows the rational allocation of resources, a reduction in operating costs, and an increase in efficiency. Dynamic pricing strategies that balance cost and customer value support long-term market sustainability.

Third, investment in innovation and staff training contributes to sustainable risk management. The automation of key processes, the deployment of smart technologies, and the promotion of a proactive risk management culture are essential elements that increase firms' adaptability.

Logistics companies that effectively manage operational risks not only reduce the likelihood of financial and reputational losses but also strengthen their market position. By strategically managing resources, implementing innovative approaches, and developing integrated management systems, they provide the stability and growth needed for long-term success in the marketplace.

2.3.3. A Process Perspective to Achieve Economic Sustainability

Aspect One: Effective management of provision stocks. The effective management of provision stocks ensures the continuity of operations and meets crew needs during voyages. This process includes coordinating orders and deliveries, as well as strategic resource management to optimise costs and reduce risks associated with supply disruptions (Christopher and Peck 2004; Deckert 2020; Cvelihárová and Pauliková 2021).

Effective supply management requires an integrated approach that encompasses some key stages such as needs analysis, inventory planning, supplier selection, and the optimisation of ordering, transportation, and storage processes. Central to this is the deployment of advanced technology and analytical tools for forecasting needs, which help identify trends and improve the accuracy of the required stock calculation. An important element in the process is supply coordination, which must take into account the specificities of maritime operations, such as voyage durations, onboard storage capacity, and the specificities of different routes. The proper planning and management of stocks allow us to avoid overstocking or shortages while reducing storage and transport costs.

Risks associated with inventory management include supply interruptions, improper storage and transport, or the non-conformance of delivered products with requirements. The implementation of strict control mechanisms, including regular inspections and quality monitoring, minimises these risks and ensures the safety and

suitability of provisions. Inventory optimisation can be achieved by implementing management models combining cost minimisation with efficiency maximisation. The application of automated inventory tracking and management systems allows logistics managers to respond quickly to changes in demand and market conditions.

Aspect Two: Effective management of delivery orders. The appropriate way to determine future delivery requirements is to examine and analyse the consumption history of provisions on previous shipping voyages. Data on the consumption of food, beverages, and other materials by category can be reviewed, and possible variations and trends can be assessed. An analysis of past provisioning requirements can provide valuable information on what can be expected for future voyages and help determine the required stocks. Once the analysis of past requirements has been performed, a forecast of future requirements should be made. Methods such as time series, statistical models, or forecasting techniques can be used to predict the quantity and type of stock that will be required for future trips. Forecasting can be based on a variety of factors such as voyage duration, crew numbers, vessel size and, therefore, the size of storage spaces, foreseeable seasonal anomalies during the voyage, and many other factors depending on the type of vessel and the budget set by the shipowner for provisioning costs.

In order to establish the possibility of supplying the necessary stocks, an assessment of the resources available on board the vessel must also be made. A review of the stocks available in the ship's stores and the possibility of sourcing from external suppliers should be carried out. The assessment of available resources can help to identify possible supply constraints or challenges and take appropriate stock management measures. Many other best practices can be applied to plan and more accurately determine the required stock levels.

Aspect Three: Optimisation of order management and provisioning and analysis of risks and opportunities for optimisation.

The management of procurement and provisioning through a strategic, methodological, and innovative approach supported by methods applied in practice can contribute to improving the economic aspect from a process perspective in several directions.

First of all, the regular monitoring and analysis of needs is an essential tool for optimal stock planning. For example, using historical consumption data on board can show that there is a significant increase in citrus consumption during the summer season. Analysing these data allows for more accurate forecasting and ensuring adequate quantities while minimising surpluses and losses. A similar approach is also applicable for planning stocks of major categories such as canned foods and cereal products, which are of strategic importance for long voyages.

Second, improving forecasting and planning processes by integrating statistical models and algorithms provides more accurate predictions of future needs. This approach allows for the optimisation of the allocation of resources such as water, food, and other essential provisions, taking into account the specific conditions of the voyage, route, and potential contingencies. This improves supply efficiency and reduces the risks of shortages or surpluses.

Third, the integration of technology solutions, such as automated inventory management systems, can help improve process accuracy and efficiency. For example,

inventory management software can automatically generate requests for provisions to be fulfilled at the next port when the level of a product falls below a predefined threshold. The system can also alert on expiry dates, ensuring that provisions are used in a timely manner and reducing the risk of loss.

Fourthly, efficient management through the introduction of GPS technologies can be used to plan optimal routes, minimising delivery times and fuel costs. In ports with a limited time window for handling, these technologies enable the timely provisioning and better coordination of cargo operations.

Fifth, the application of appropriate methods can achieve flexibility and adaptability to emergency situations. For example, during the COVID-19 pandemic, the availability of alternative suppliers and buffer stocks of long-life products, such as canned and frozen foods, ensured the continuity of operations despite port constraints. Additionally, shifting supplies to alternate ports demonstrated the strategic importance of advance planning.

Sixth, effective cooperation with suppliers is based on long-term partnerships and establishing clear terms of business. For example, established suppliers of fresh vegetables can provide emergency supplies in exceptional circumstances, with agreed terms including rapid response and high-quality produce. Regular assessments of suppliers against criteria such as punctuality, reliability, and quality of service ensure transparency and stability in supply.

Seventh, the implementation of sustainable practices contributes to both economic efficiency and environmental protection. For example, replacing single-use plastic packaging with reusable containers minimises waste and costs. Using energy-efficient refrigerated containers to transport frozen food reduces the carbon footprint of the supply chain while ensuring product quality.

By integrating the approaches and examples described, organisations can achieve significant improvements in order management and provisioning. This leads not only to reduced operational costs and minimised risks but also to better sustainability and competitiveness in the dynamic environment of maritime operations.

2.3.4. A Learning and Development Perspective

- Aspect one: Professional training for process optimisation.

Vocational training for process management in maritime supply is an essential element of the perspective of economic sustainability. It aims to ensure a high degree of efficiency, quality, and sustainability in all aspects of provisioning operations. First and foremost, training should include skills for effective stockpile management. For example, staff can be trained to use specialised inventory management software systems that automatically update stock levels and suggest optimal orders based on current consumption. This prevents losses from overstocking and ensures that the necessary resources are available without unnecessary costs.

Secondly, training should cover ordering and delivery processes, including negotiating with suppliers and selecting sustainable transport options. For example, a supply management course could include simulations of negotiating supply terms with alternative suppliers in a crisis, such as natural disasters or logistical delays.

Practical examples could include analysis of scenarios where supplies need to be diverted to alternate ports.

Thirdly, training programmes should also include food quality and safety standards such as HACCP (Hazard Analysis and Critical Control Point). For example, training modules can demonstrate how the crew can identify and prevent cross-contamination during food processing using good hygiene practices and proper product storage. This is particularly important for maintaining the quality and freshness of provisions on long voyages.

Fourth, training should prepare staff to innovate in supply chains. For example, training using IoT (Internet of Things) devices could include working with sensors to track real-time temperature and humidity to ensure that provision storage conditions remain optimal.

- Second aspect: Interdisciplinary approach and collaboration.

An opportunity for development is the creation of interdisciplinary teams that bring together expertise in logistics, procurement, technology, and finance to develop innovative solutions to optimise costs and increase efficiency in procurement. This collaborative fit-for-purpose strategy not only improves resource management but also reduces the risks associated with supply chain disruptions, ensuring a more sustainable and adaptive logistics operation.

Firstly, an interdisciplinary approach provides an opportunity for synergies between different specialisations, which supports the development of innovative solutions. For example, collaboration between quality management and technology teams can lead to the deployment of IoT sensors to monitor provisioning storage conditions, allowing for a reduction in losses from improper storage and the optimisation of operational processes.

Secondly, collaboration between key departments such as procurement, logistics, and operations creates the opportunity for better risk management. Through joint efforts, alternative logistics routes can be developed that ensure uninterrupted supplies in the event of natural disasters or other unforeseen situations. This increases supply chain resilience and improves the continuity of operations.

Thirdly, the integration of finance and logistics through joint working groups creates the opportunity for the more efficient allocation of resources and better cost control. For example, the combined analysis of financial data and logistics operations can reveal the potential to optimise transport costs by consolidating deliveries or selecting more profitable logistics solutions. This contributes to increasing economic efficiency and reducing overall operating costs.

Fourthly, the organisation of regular training and knowledge sharing between departments can encourage the expansion of expertise. For example, holding training sessions where a technology team demonstrates the use of automated inventory management systems can help procurement and logistics departments optimise their processes.

Fifth, the creation of communication platforms for information exchange can improve operational efficiency. For example, the use of advanced software tools such as common planning and management platforms allows different departments to share real-time information on inventory, supplies, and demand forecasts.

Sixth, the creation of project working groups for specific tasks or problems can provide focused and effective solutions. For example, when a delivery is delayed, a team of logistics and technology specialists can quickly identify the problem and implement a solution by rerouting or coordinating with alternative suppliers.

By fostering a culture of collaboration and innovation, maritime companies can prepare for the challenges of the modern transport market. This not only improves efficiency but also strengthens the sustainability and competitiveness of organisations.

- Third aspect: Introducing technological innovations in procurement.

Onboard provisioning represents one of the major challenges for maritime operators, requiring the implementation of technological innovations to optimise processes and increase efficiency. The main aspects of innovation and their practical applications should be considered.

First of all, the implementation of intelligent inventory and order management systems can help to optimise procurement processes. For example, the use of demand forecasting algorithms allows operators to analyse historical data and predict future requirements. The introduction of e-commerce platforms and cloud-based systems can help generate orders and interact with suppliers quickly while reducing administrative costs.

Secondly, the introduction of automated warehousing and provision handling systems can organise and store goods appropriately based on their category, expiry date or frequency of use. This would allow the quick retrieval of needed provisions, reducing handling time and minimising human error.

Thirdly, the use of the Internet of Things (IoT) and sensor technologies represents a significant opportunity for development, providing the real-time tracking of goods and enabling precise control over transportation and storage conditions. Sensors placed on food containers can monitor key parameters such as temperature and humidity, allowing for the timely detection of problems and minimisation of wastage.

Fourth, digital supply management platforms can integrate all processes into a single system. Through the use of demand forecasting, supply planning, and inventory management tools, these platforms facilitate coordination between supply chain actors and improve operations.

Fifth, the deployment of artificial intelligence (AI) provides new opportunities for development by automating and optimising processes. AI solutions can analyse large volumes of data, identify patterns in consumption, and recommend optimal order quantities. Additionally, through route optimisation algorithms, AI systems can suggest the most efficient logistics solutions, taking into account factors such as weather and traffic conditions.

Sixth, the integration of automated systems and the IoT can improve inventory and order management across the board. For example, automated inventory systems can send alerts about low stock levels and automatically generate orders to suppliers. This reduces response times and minimises the risk of shortages.

The systematic implementation of innovative technologies represents a significant potential for developing maritime operators while opening up new opportunities for optimising supply processes. By integrating advanced technology

solutions, operators can not only achieve higher efficiency and significant cost reductions but also increase the sustainability of their operations in the long term. In addition to facilitating ongoing supply management, these solutions create a strategic platform for future improvements aimed at making supply chains more adaptable and resilient to changing conditions in the global logistics environment.

2.3.5. Conclusions from Chapter Two

This chapter focuses on the economic sustainability of shipboard provisioning, looking at it from different perspectives. The chapter focuses on the importance of economic sustainability in provisioning supply processes. The research conducted confirms the hypothesis that the optimisation of inventory management and processes contributes to cost reduction, quality improvement, and increased crew satisfaction. The findings reflect the need for focused efforts towards improving logistics practices and implementing innovative approaches.

The methodology used, combining surveys and interviews with professionals, ensures a high degree of representativeness and reliability in the research. The integration of perspectives from different disciplines enriches the analysis and contributes to a holistic picture of the processes. This approach highlights the importance of interdisciplinarity and collaboration in successfully addressing the identified challenges.

The analysis reveals certain difficulties related to regulatory compliance, risk management, and security, as well as the need to improve staff motivation schemes. The correlation analysis shows significant relationships that highlight the impact of the frequency of improvements made in supply chain performance. At the same time, well-structured forecasting and inventory management processes minimise wastage and ensure sustainable supply.

Technological innovations, including the IoT, artificial intelligence, and blockchain technologies, demonstrate significant potential to improve the accuracy, transparency, and efficiency of processes. The technologies introduced, combined with an interdisciplinary approach and effective cross-departmental collaboration, create opportunities for innovative solutions and enhance the competitiveness of organisations.

This chapter outlines the main challenges and opportunities for supply chain optimisation in the supply of ship provisions. The findings confirm the need for an integrated approach that combines technological innovation, regulatory compliance, and strategic risk management. These aspects form the basis for the creation of a Balanced Scorecard (SBSC) that brings together different perspectives—financial, consumer, process, and learning—to achieve sustainability and competitiveness.

Applying the lessons learned to real-world strategies will assist maritime operators in meeting the challenges of today's industry while driving the development of efficient, sustainable, and innovative supply chains.

3. Social Sustainability in Provisioning

Chapter Three of this study focuses on social sustainability in provisioning for seagoing ship crews. It analyses and evaluates various aspects of provisioning practices, discussing the methodology of the study, the objectives, the methods of data collection and analysis, and a questionnaire to investigate the practices in place. The financial perspective of social sustainability is explored through an analysis of acceptable working conditions and pay, investment in socially responsible initiatives, and transparency and accountability for social impacts. The consumer perspective in this chapter includes issues such as ensuring access to high-quality food, ethical and socially responsible products, and supporting community needs and values. The process perspective of social sustainability in provisioning merchant ship crews includes effective supply chain management, improved working conditions, and transparency and accountability related to social sustainability. The last part of this chapter discusses perspectives on social sustainability training and development, focusing on the reduction in discriminatory regulations, socially responsible training, and collaboration with educational institutions and NGOs. It is found that the aspects studied help achieve social sustainability in the supply chain of food provisions for maritime crews by ensuring fairness, ethics, and responsibility.

3.1. Analysis and Evaluation of Provisioning Practices

Providing high-quality food for sea crews requires compliance with international norms and standards for nutrition, as well as compliance with hygiene and safety regulations. Although the aspiration of provisioning processes is to cater for the diverse cultural and religious preferences of seafarers, the food on board is often constrained by factors such as budget, the availability of raw materials, and preparation capabilities. Various factors have been found to have the potential to contribute to limiting the variety and quality of meals offered. In addition, the choice and quality of provisions can vary depending on the class of crew, with crew members often split into different dining venues depending on their status.

Ship crews have been found to face significant challenges in providing food, such as a lack of self-determination in food choices, the limited variety and quality of products offered, and irregular meal intervals due to the specifics of their work schedules. The aspects presented highlight the need to investigate the existing conditions in order to identify the essential reasons for improving the state of food provisions on board ships to maintain the optimal physical and mental health of crews (Ajayi and Udeh 2024).

Introducing specific norms and standards for food quality and variety can help to reduce these challenges and improve the nutritional conditions on board ships. Conducting surveys can provide valuable information that can serve as a basis for introducing improvements to the shipboard feeding system.

Food is not just a means of ensuring vital functions and performance but also a source of comfort, pleasure, and psychological stability. Conducting this study is a step towards understanding the needs and preferences of crews and identifying areas for improvement in the food delivery system. Based on the information obtained,

recommendations can be made to optimise the logistics and management of food resources on board ships, improving seafarers' living and working conditions and contributing to increased shipping efficiency and safety.

Food provisions play a critical role in crews' health, well-being, and efficiency during extended sea voyages. In this context, this research study focuses on the investigation and analysis of crews' perceptions and needs regarding onboard nutrition. Specifically, the research aims to analyse crews' perception of the importance of providing food and to identify factors that can improve the quality and conditions of onboard nutrition.

3.2. Social Resilience Survey Methodology

3.2.1. The Objective of the Study

The aim of this study is to investigate the social aspect of sustainability related to the supply of food provisions on board seagoing ships and how they affect the health and performance of the crew. The research sources and analyses reviewed show that the quality and quantity of food are critical to the physical and mental well-being of the crew, which affects their performance, especially during extended voyages.

This study aims to assess crew perceptions on the social aspect of sustainability, focusing on the importance of the proper management of food supplies, their quantity and quality, and how these factors affect the overall health and performance of the crew. The research will help to optimise logistics and food stock management while improving crew welfare and ship efficiency.

The thesis of this study is that there is a statistically significant correlation between crew assessment of the state of food provisions and the social aspect of resilience, such as crew health and performance. This highlights the importance of the proper management of the quantity and quality of food provisions for the crew's social resilience while at sea.

In this context, the formulated hypotheses are the following:

Null Hypothesis (H_0): The null hypothesis is that there is no statistically significant correlation between the crew's assessment of the state of food provisions on board and the social aspect of resilience, such as crew health and performance. In other words, the coordinates in the correlation matrix are not significantly different from 0 at the alpha = 0.05 level of significance.

Acceptable Hypothesis (H_1): The acceptable hypothesis is that there is a statistically significant correlation between crew assessment of the state of food provisions on board and the social aspect of resilience, such as crew health and performance. This is expressed with a significance (p-value) of less than 0.05, indicating a strong correlation between these variables.

3.2.2. Study Participants

The survey was conducted with the same 98 respondents who participated in the previous survey but with a new focus on the social aspect of resilience related to crew health and performance. The participants were the same managers or executives of logistics companies, business owners, logistics and supply chain

management professionals, and employees responsible for inventory management and food procurement.

The data from the second study were analysed in the context of social resilience, and their interpretation will enable a deeper understanding of the interaction between delivery performance and social factors related to crew performance and well-being. The methods used for data collection, participant selection, and anonymity remained unchanged, as did the guarantee of the confidentiality of the information collected. Although random samples are usually used for data collection, when the same participants are observed repeatedly, conclusions can be more accurate and substantiated (Zumkeller et al. 2006).

The personal identification of participants was protected by removing all personal data from the collected questionnaires. Each participant was given a unique code that identified them without revealing their identity. Data were stored in a secure environment, and all necessary measures were taken to protect against unauthorised access. Only authorised persons had access to these data and were aware of the rules for their processing and confidentiality. The participants were informed in advance of the purposes of this study and the processing of their data and gave their consent to participate.

3.2.3. Data Collection Method

The method of data collection used for the second study was through questionnaires and interviews with the participants. The main focus of this stage of the study was on the social effects of provisioning and its impact on crew health and performance. Similar studies where the same participants are engaged in different stages of research are widely used. For example, in panel studies, the same sample of participants can be observed repeatedly to draw meaningful conclusions from changes in their behaviour and perceptions over time (Slattery et al. 2011). Moreover, when we use the same participants for different studies, this allows for the better tracking of social and economic changes in their perceptions (Zamenopoulos and Alexiou 2018).

The participants were asked to complete the questionnaire by highlighting the answer they thought was correct and placing an "x" in the box next to the corresponding answer number. The questionnaire was printed on paper and distributed to each crew member in person or through a representative of the team conducting the survey. This method was chosen as appropriate because the crew did not have easy access to electronic devices using internet services, and for these reasons, questionnaires were distributed to crew members on paper during training, meetings, or other events.

3.2.4. Data Analysis Method

The data collected from the questionnaire were processed and analysed to extract key findings and trends, with the main focus being on the social aspect of sustainability in the supply of food provisions on board ships. Statistical methods of analysis used included correlation analysis, which allowed for the identification of

relationships between different aspects of crew perceptions of food provisioning and their impact on social resilience, health, and performance.

The data were analysed as aggregated information without using specific identifiers of individual participants to protect their anonymity and confidentiality. The main aspects of this study relate to exploring the importance of crews having a reliable food supply and clarifying how this affects their social well-being and performance during voyages.

Through the analysis of the data collected, the frequency and severity of problems with an excess or shortage of food provisions, as well as their quality, were determined. This study helped to assess the perceptions of different crew members on the importance of the variety and quality of food offered on board. The focus was on how the effective management of food supplies affects crew health and performance, which is an important element for social sustainability.

In order to establish the relationship between the different aspects of food provisions and crew satisfaction, a statistical treatment of the data obtained was performed using Spearman's correlation coefficient. The calculation of this coefficient was carried out using the XLSTAT software package (Addinsoft 2024), which provides specialised functions to automatically calculate the correlation based on the results of questionnaires. The Spearman correlation coefficient found in the analysis allowed the general preferences of the crew to be explored and, after subsequent interpretation, adequate conclusions to be drawn about the social sustainability of food provisioning (Beall 2017; Arora et al. 2022; Chaghooshi et al. 2015; Vachon and Mao 2008; Wahyuni 2024).

3.2.5. Survey Questionnaire Social Aspect

In order to ensure the objectivity and reliability of the data, the questionnaire included (Table 5) a number of questions that related to different aspects of the research problem. The questionnaire was presented as a table with a set of questions, and a five-point rating scale was provided for each question.

Table 5. The crew attitude questionnaire to assess their perceptions of the importance of onboard provisioning.

Answers	Questions
☐ 1: Almost never ☐ 2: Very rare ☐ 3: Rarely ☐ 4: Often ☐ 5: Very often	Q1. How often do you encounter problems related to excess or shortage of provisions on board the ship
☐ 1: Not relevant ☐ 2: Little Importance ☐ 3: Average ☐ 4: Great importance ☐ 5: Huge Importance	Q2. How would you rate the importance of proper management of provisions for the overall health of the crew?

Table 5. *Cont.*

Answers	Questions
☐ 1: Not relevant ☐ 2: Little Importance ☐ 3: Average ☐ 4: Great importance ☐ 5: Very great importance	Q3. How would you rate the importance of maintaining an adequate amount of food provisions for the entire sailing period?
☐ 1: Not relevant ☐ 2: Little Importance ☐ 3: Average ☐ 4: Great importance ☐ 5: Huge Importance	Q4. How important is it for you to have a quality and varied range of food provided on board?
☐ 1: Very dissatisfied ☐ 2: Rather dissatisfied ☐ 3: Neutral ☐ 4: Great importance ☐ 5: Huge Importance	Q5. Please give a general assessment of the state of food provisions at work, taking into account both their availability and quality.
Importance of short answers to question 5 Very dissatisfied: Food provisions are in an unacceptable state, both in terms of availability and quality. Serious problems are present, which hinder the normal functioning of the crew. Rather Dissatisfied: The condition of food provisions is below average, with some gaps or problems in both the availability and quality of food offered. Neutral: Food provisions are in satisfactory condition. Availability and quality are acceptable, but there is room for improvement and optimisation of the overall supply chain. Satisfied: the condition of the food provisions is good. A variety of good quality products are available to meet the needs of the crew. Very pleased: the food provisions are in extremely good condition. Availability and quality are of a high standard, with the food on offer in sufficient quantity and excellent.	

Source: Table by author.

3.3. Interpretation of Survey Results

The crew opinion survey on the social aspect of food provisioning provides interpretable data for understanding the most important aspects, such as the frequency of stock problems, the importance of proper food stock management, and the importance of food quality and variety. An analysis of these data shows a high degree of agreement among respondents on the importance of these factors, which is reflected in the following key statistics.

3.3.1. Averages from the Questionnaire

The table of summary statistics of the quantitative data (Table 6) shows that all variables have mean values close to the maximum, indicating a high score given

by the respondents. For example, the mean of the question on the frequency of stock problems (Q1) is 4.439, with a standard deviation of 0.610, indicating that most responses are clustered around the high scores. The situation is similar in terms of the importance of proper food inventory management to crew health and productivity (Q2), where the mean is 4.571 with a standard deviation of 0.537.

Table 6. Summary statistics (quantitative data).

Variable	Observations	Minimum	Maximum	Mean	Std. Deviation
Q1	98	3000	5000	4439	0.610
Q2	98	3000	5000	4571	0.537
Q3	98	3000	5000	4531	0.613
Q4	98	2000	5000	4102	0.843
Q5	98	3000	5000	4429	0.592

Source: Table by author.

An analysis of the data shows that the importance of maintaining adequate food supplies for the entire sailing period (Q3) and the importance of the quality and variety of food provided (Q4) also received high ratings, with averages of 4.531 and 4.102, respectively. Although the scores for quality and variety of food have a larger standard deviation (0.843), indicating a larger variance in responses, the overall score for the status of food stocks (Q5) is also high at 4.429, with a standard deviation of 0.592.

3.3.2. Correlation Matrix

The correlation matrix reveals important relationships between different aspects of food inventory management and crew perceptions of their importance and quality (Table 7).

Table 7. Correlation matrix.

Variables	Q1	Q2	Q3	Q4	Q5	3	4	5
Q1	1	0.548	0.529	0.633	0.872	−0.320	−0.747	0.887
Q2	0.548	1	0.823	0.484	0.583	−0.335	−0.393	0.540
Q3	0.529	0.823	1	0.553	0.589	−0.354	−0.383	0.538
Q4	0.633	0.484	0.553	1	0.676	−0.470	−0.382	0.589
Q5	0.872	0.583	0.589	0.676	1	−0.562	−0.684	0.931
3	−0.320	−0.335	−0.354	−0.470	−0.562	1	−0.218	−0.223
4	−0.747	−0.393	−0.383	−0.382	−0.684	−0.218	1	−0.903
5	0.887	0.540	0.538	0.589	0.931	−0.223	−0.903	1

Source: Table by author.

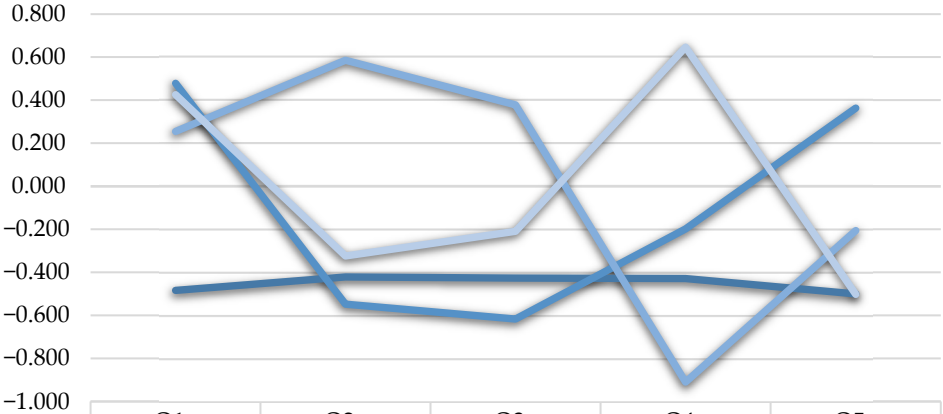
The strong positive correlations between the frequency of stock problems (Q1) and the overall stock condition score (Q5) (0.872) indicate that the more frequent the stock problems are, the lower the overall stock condition score is. The importance of proper food inventory management to crew health and productivity (Q2) has a strong positive correlation (0.823) with the importance of maintaining adequate stocks for the entire voyage (Q3), highlighting the importance of proper inventory management in ensuring sufficient food throughout the voyage.

The importance of maintaining adequate food stocks (Q3) has a moderate positive correlation (0.589) with the overall assessment of food stock status (Q5), indicating that maintaining adequate stocks is important to the overall assessment of their status. The importance of food quality and variety (Q4) also has a positive correlation (0.553) with maintaining adequate stocks, highlighting the importance of having a variety and high quality of food for the entire voyage.

Negative correlations with additional variables suggest that the better management of these aspects could significantly reduce stock problems and improve overall stock assessment. For example, the third variable (3) has a moderate negative correlation with the frequency of stock problems (Q1, −0.320) and the overall stock condition score (Q5, −0.562), indicating that the better management of this variable leads to fewer problems and a better stock condition score. The fourth variable (4) has a strong negative correlation with the frequency of inventory problems (Q1, −0.747) and the overall assessment of food inventory status (Q5, −0.684), highlighting that the better management of this variable significantly reduces inventory problems and improves overall stock assessment.

3.3.3. Interpretation of *p* Vectors

The figure with *p* vectors (Figure 3) presents the results of the factor analysis, which reveal the principal components (*p*1, *p*2, *p*3, *p*4) and their impact on the different variables. The interpretation of these vectors provides a deeper understanding of the factors that influence different aspects of the social perceptions of food provisions on board ships.



	Q1.	Q2.	Q3.	Q4.	Q5.
*p*1	−0.484	−0.421	−0.426	−0.429	−0.500
*p*2	0.479	−0.548	−0.617	−0.199	0.363
*p*3	0.254	0.586	0.378	−0.910	−0.206
*p*4	0.425	−0.324	−0.209	0.647	−0.502

Figure 3. The *p* vectors. Source: Figure by author.

The first variable (Q1), which looks at the frequency of inventory problems, has significant correlations with all four components. The strong negative correlation with $p1$ (-0.484) and positive correlations with $p2$ (0.479) and $p4$ (0.425) indicate that stock problems are significantly affected by both $p1$ and $p2$ and $p4$. This suggests that these components play an important role in determining the frequency of stock problems.

The second variable (Q2), which assesses the importance of proper food inventory management for crew health and productivity, has negative correlations with $p1$ (-0.421) and $p2$ (-0.548) but a positive correlation with $p3$ (0.586). This indicates that $p3$ is a significant positive contributor to proper food inventory management, while $p1$ and $p2$ have the opposite effect.

The third variable (Q3), related to the importance of maintaining adequate stocks for the entire sailing period, has the strongest negative correlation with $p2$ (-0.617) and a positive correlation with $p3$ (0.378). This variable is most strongly influenced by $p2$, showing a significant negative effect, while $p3$ has a positive effect.

The fourth variable (Q4), which assesses the importance of the quality and variety of food provided, has a strong negative correlation with $p3$ (-0.910) and a positive correlation with $p4$ (0.647). This indicates that $p3$ has a significant negative effect on the perception of quality and variety of food, while $p4$ has a positive effect.

The fifth variable (Q5), which provides an overall assessment of the state of food stocks, has the strongest negative correlation with $p1$ (-0.500) and $p4$ (-0.502) and a positive correlation with $p2$ (0.363). These results indicate that $p1$ and $p4$ have a significant negative effect on the overall score, while $p2$ has a positive effect.

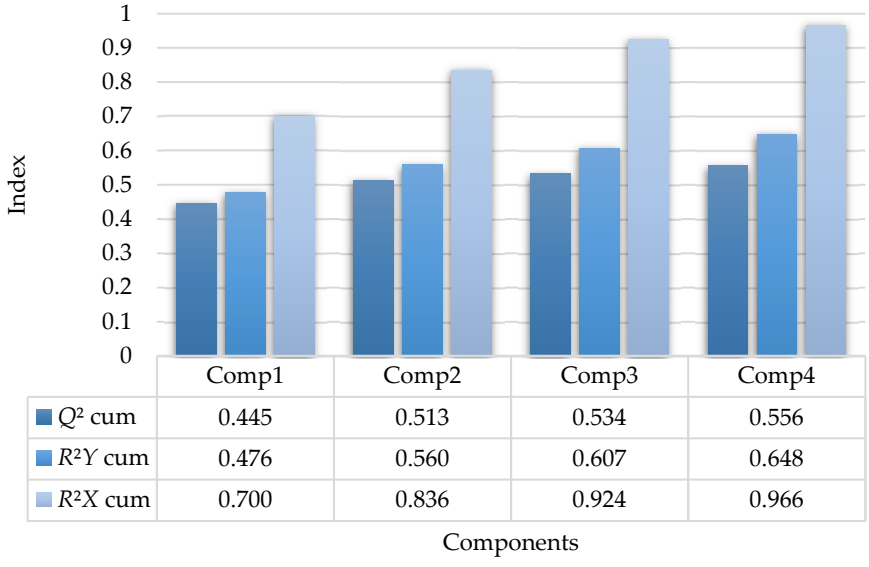
The interpretation of the p vectors reveals the important factors that influence different aspects of the delivery of food provisions on board the ship. The various components show specific relationships and influences on the frequency of stockpile problems, the importance of proper stockpile management, the maintenance of adequate stockpiles, the quality and variety of food, and the overall assessment of the state of food stocks.

The results of the analysis of the p vectors provide the basis for the development of a Balanced Scorecard (SBSC) for the social sustainability of food provisions.

3.3.4. Interpretation of Model Quality by Number of Components

The results of the assessment of the interpretative and explanatory power of the model are presented in Figure 4. The figure contains the cumulative values of Q^2, R^2Y, and R^2X for the four components (Comp1, Comp2, Comp3, Comp4).

The cumulative values of Q^2, which range between 0.445 and 0.556, indicate that the model is effective. The highest value of Q^2 is 0.556 for the fourth component (Comp4), suggesting that this component has the strongest interpretative power among all the components and that Comp4 most accurately explains the variation in the dependent variables. The cumulative values of $R^{(2)}Y$ are also relatively high, ranging from 0.476 for the first component (Comp1) to 0.648 for the fourth component (Comp4). The values confirm that the explanatory power of the model with respect to the dependent variables is significant. Again, the fourth component demonstrates the greatest strength, explaining most of the variation in the dependent variables.



	Comp1	Comp2	Comp3	Comp4
Q^2 cum	0.445	0.513	0.534	0.556
R^2Y cum	0.476	0.560	0.607	0.648
R^2X cum	0.700	0.836	0.924	0.966

Figure 4. Model quality by number of components. Source: Figure by author.

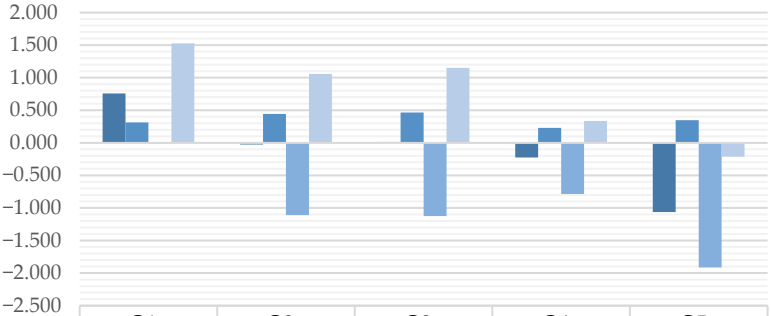
The cumulative values of R^2X are very high, ranging from 0.700 for the first component (Comp1) to 0.966 for the fourth component (Comp4). These values indicate that the model explains much of the variation in the independent variables, with the fourth component explaining almost all of the variation.

An analysis of model quality shows that all components have good interpretative and explanatory power. The fourth component (Comp4) demonstrates the highest values of Q^2, R^2Y, and R^2X, making it the strongest component in the model. The results indicate that the model is robust and can be used to interpret and explain variation in the dependent variables, and the data obtained from the analysis can be used to develop a Balanced Scorecard (SBSC) for the social resilience of food provisions.

3.3.5. Standardised Coefficients

The figure of standardised coefficients shows the influence of various factors on the overall assessment of the state of the food stocks at the time of the operation, considering their availability and quality (Figure 5).

The first variable (Q1), which looks at the frequency of problems related to an excess or shortage of food provisions on board a ship, has a positive standardised coefficient of 0.758 with a standard deviation of 0.314. This suggests that the frequency of these problems has a significant impact on the overall assessment of the state of food stores. Although the lower bound of the 95% confidence interval is just below zero (−0.010), the upper bound (1.525) exceeds zero significantly, suggesting that the influence of this variable is significant but may have variability.



	Q1.	Q2.	Q3.	Q4.	Q5.
Coefficient	0.758	−0.026	0.013	−0.226	−1.063
Std. deviation	0.314	0.443	0.465	0.229	0.348
Lower bound (95%)	−0.010	−1.111	−1.126	−0.785	−1.914
Upper bound (95%)	1.525	1.058	1.152	0.334	−0.213

Figure 5. Standardised coefficients (95% conf. interval). Source: Figure by author.

The second variable (Q2), which assesses the importance of proper food management to crew health and productivity, shows a standardised coefficient of −0.026 with a standard deviation of 0.443. The confidence interval (−1.111 to 1.058) spans zero, indicating that this coefficient is not statistically significant and does not significantly affect the estimate.

The third variable (Q3), related to the importance of maintaining adequate food stocks throughout the cruise period, has a very small positive standardised coefficient of 0.013 with a standard deviation of 0.465. Similarly to Q2, the confidence interval (−1.126 to 1.152) spans zero, suggesting no significant influence.

The fourth variable (Q4), which assesses the importance of the quality and variety of food provided, has a negative standardised coefficient of −0.226 with a standard deviation of 0.229. The confidence interval (−0.785 to 0.334) also spans zero, indicating that this impact is not statistically significant, although the trend is towards a negative impact.

The fifth variable (Q5), which represents the overall assessment of food stock status, has a significant negative standardised coefficient of −1.063 with a standard deviation of 0.348. The confidence interval (−1.914 to −0.213) is entirely negative, highlighting the significance of this coefficient and indicating that a low assessment of the condition of food stocks has a strong negative impact on the perception of their quality and availability.

An analysis of the standardised coefficients indicates that the frequency of stock problems (Q1) is a major factor significantly influencing the social aspect and crew perception of the food stock status. However, other variables, such as the importance of proper inventory management and food quality (Q2, Q3, and Q4), do not show statistically significant impacts. On the other hand, the variable Q5, which reflects the overall assessment of food stock status, has a significant negative effect, highlighting the need for attention to the management and quality of the stock on board.

The results were used to develop strategies to improve the social aspect of onboard food management, with a focus on reducing stock-holding problems and improving the quality and variety of food to increase crew satisfaction.

3.4. SBSC—Social Sustainability of Ship Provisions

The analysis of the survey results was used as the basis for the compilation of a Balanced Scorecard (SBSC) focused on the social sustainability of food provisioning on board seagoing ships. The survey data collected through the questionnaire provided important information on the importance of effective management of food supplies and their impact on social well-being and crew performance.

The financial perspective is designed to optimise processes and costs, highlighting the importance of reducing losses arising from inventory issues. This will not only allow for improved economic sustainability but will also support the social stability of the crew by ensuring stable resources.

The consumer perspective emphasises the importance of proper inventory management to crew health and productivity. The survey data show that food quality and variety are critical to crew well-being, which is not only a social but also an economic aspect of sustainability.

The process perspective focuses on minimising the risk of supply chain disruptions, taking into account high estimates of the importance of maintaining adequate food provisions while afloat. This will ensure stability and predictability in supply processes.

The training and development perspective highlights the need for professional training and motivational programmes that will increase delivery efficiency and promote sustainable resource management by the crew.

Integrating these perspectives into the SBSC provides a holistic approach to food provisioning supply management that supports both economic and social sustainability while addressing all of the key challenges identified in the analysis of the survey data. Table 8 discusses four main perspectives of social sustainability: financial, consumer, process, and learning and development perspectives. The perspectives provide a framework for assessing and improving social aspects in the supply chain, with attention to different stakeholders and their needs.

According to a study by Schönborn et al., there is a strong positive relationship between the corporate culture of social sustainability and financial success, and they identified four key dimensions related to success, including sustainability strategy and leadership; mission, communication, and learning; welfare and work life; and loyalty and identification (Gharehgozli et al. 2017). In the context of the social perspective, investing in higher-quality provisions not only reduces the risks of illness and inconvenience to crews but also ultimately reduces medical costs and absenteeism. Also, providing varied and tasty food can increase crews' motivation and satisfaction, which improves their productivity and efficiency. From a consumer perspective, high-quality provisions that meet crews' cultural and dietary preferences are essential to their physical and psychological well-being. Access to a variety of food options provides satisfaction and comfort to crews, which improves their overall psychological stability. The process perspective highlights the importance of effective supply chain management and quality control for provisions. Logistics

optimisation and quality control systems can provide faster and more efficient access to food resources while ensuring the safety and satisfaction of crews. The training and development perspective highlights the importance of training crews in social skills, conflict management, and stress resilience. Training can improve the social atmosphere of ships and increase the productivity and efficiency of crews. All these aspects make up important components of a strategy to achieve social sustainability in the provisioning industry.

Table 8. Social sustainability in provisioning.

3.2.1. Financial Perspective on Social Sustainability	**3.2.2. Consumer Perspective on Social Sustainability**	**3.2.3. Process Perspective on Social Sustainability**	**3.2.4. Perspective for Learning and Development of Social Sustainability**
- Ensuring decent working conditions and fair pay for workers in the supply chain with provisions. - Investing in socially responsible initiatives. Supporting investments in socially responsible initiatives that support communities affected by the company's operations or its suppliers. - Transparency and accountability for social impacts. Providing information about the social programmes and initiatives they support and their efforts to improve the working and living conditions of the communities that are part of their business.	- Ensuring access to high-quality food. - Ethical and socially responsible products. Customers are increasingly interested in products that produce social value and support society. - Transparency and accountability for social initiatives. Customers value transparency and accountability regarding social initiatives, and a commitment to social responsibility can improve consumer trust and drive them to more sustainable brands.	- Effective supply chain management—the control and monitoring of social aspects throughout the supply chain and implementing measures to manage the risk of labour exploitation and violations of workers' rights. - Improving working conditions for workers in the supply chain—social labour standards and appropriate measures to ensure safety and good working conditions.	- Reducing discriminatory provisions. Recruiting, training, and retaining a skilled workforce. - Socially responsible staff training. Cooperation with educational institutions and NGOs. Organisations with experience and expertise in social issues and workers' rights—knowledge and practice sharing, as well as training and development programmes for workers in the supply chain.

Source: Table by author.

3.4.1. A Financial Perspective on Social Sustainability

- The first aspect relates to acceptable working conditions and pay.

Decent working conditions and fair pay for workers in the supply chain with provisions should be ensured. It should also be ensured that suppliers respect social labour standards and do not exploit or violate workers' rights. There is a specific combination of requirements and conditions unique to the maritime industry that can create workplace hazards rarely found in other industries. Fatigue, stress, work pressures, communication problems, environmental factors, and long periods away from home are just some of the potential factors that can affect the safety and efficiency of shipping. In order to improve the social sustainability of provisioning and reduce risks and hazards in the workplace, more attention needs to be focused on the study of human factors in the maritime industry. Continuous analysis should be carried out to identify potential risks and target efforts to improve the working environment and working conditions on ships. As a result, this can contribute to greater safety, efficiency, and social sustainability in shipping and provisioning. Furthermore, the importance of the social organisation of personnel on board cannot be underestimated. Insufficient attention to the social aspects of onboard work can lead to reduced motivation and increased stress and conflict, which can ultimately jeopardise ship safety and provision delivery.

The development of social sustainability in the context of provisioning for seagoing crews cannot be considered without attention to the financial perspective, including acceptable working conditions and pay. This can be carried out through the following main approaches:

First is considering economic pressures and their impact on social sustainability. In a competitive environment, logistics organisations often face economic constraints and tight supply budgets for provisions, which can lead to reduced spending on food and other essential resources. This can negatively impact social sustainability by reducing the quality and nutritional value of food, which could consequently affect crew motivation and satisfaction (Potharla et al. 2024).

Second is investment in insurance mechanisms and risk management. The introduction of appropriate insurance systems and effective risk management can ensure the security of provision delivery and protect maritime operators from losses in the event of incidents or accidents on board. The lack of adequate insurance mechanisms may lead to instability in the supply of provisions, which call into question the social sustainability of these supplies.

Third, the quality and variety of food must be ensured. In order to ensure the social sustainability of provisioning, attention must be paid to the quality and diversity of the food provided and the social and economic conditions that may influence the provisioning process. This includes investment not only in infrastructure but also in risk management, creating favourable social conditions on board ships.

The measures presented must be integrated to ensure maritime crews' social sustainability and create the conditions for a positive impact on their satisfaction and work motivation.

As a result, crews can offer more efficient and higher-quality service to ships, which contributes to the smoother and more successful execution of work tasks. So, in addition to being a means of satisfying physical needs, the food and beverages on board also play a role in creating the right working environment and increasing crew motivation. Improved motivation and job satisfaction have the potential to improve overall shipping productivity and performance, contributing to greater social sustainability in provisioning and seagoing personnel performance.

- The second aspect is investment in socially responsible initiatives.

Traditional business objectives, primarily profit-driven, are undergoing significant changes, with logistics companies having to play an active role in addressing social and environmental challenges. Investing in socially responsible initiatives is important to achieve sustainable and beneficial development. The following aspects can help implement these initiatives:

First is support for socially responsible initiatives. Corporate Social Responsibility (CSR) provides opportunities for companies to contribute to solving social and environmental problems such as poverty, unemployment, and pollution. By supporting these initiatives, companies can demonstrate their commitment to social and environmental sustainability, which strengthens their reputation and competitiveness.

Second is long-term benefits for the company. Investing in community initiatives creates an opportunity to build closer ties with local communities and better understand their needs. This can lead to the development of more successful products and services that respond to communities' preferences, thereby enhancing social sustainability and growing satisfaction with the services provided.

Third is creating a sustainable business environment. Supporting socially responsible initiatives helps create a more stable economy and reduce social tensions. When businesses commit to improving living conditions in affected communities, this leads to healthier economic relations and a reduction in conflicts that can arise from social inequalities.

Fourth is improving companies' public reputation and brand. Companies that engage in socially responsible initiatives are often perceived as ethical and socially responsible. These efforts lead to improved public reputation and increased consumer and investor confidence, which can positively affect businesses' long-term success.

Investing in socially responsible initiatives is an important practice that not only brings benefits to society but also creates opportunities for sustainable development for a company itself by demonstrating its commitment to social and environmental sustainability.

- The third aspect relates to transparency and accountability for social impacts.

The financial sustainability of modern companies involves not only financial performance but also a commitment to social responsibility. This commitment is essential to any company's success, as social responsibility and transparency play an important role in today's business world. The social impact reporting process covers the following key aspects:

First is providing information on social programmes and initiatives. An increasing number of organisations are providing information about the social programmes and initiatives they support, and these efforts aim to improve the working and living conditions of the communities that are part of the business. This is an important element in increasing company credibility and establishing a strong reputation in the marketplace. Providing clear and transparent information about social commitments and their outcomes helps strengthen stakeholder attitudes towards the company (Walters et al. 2024).

Second, ethical standards and social responsibility must be achieved. Logistics organisations that actively engage with social issues and work to solve them are perceived as more ethical and responsible. These efforts not only improve relationships with consumers but also strengthen the companies' position in the marketplace and create conditions for longer-term success. Social responsibility is not only a moral obligation but also a strategic tool for business growth.

Third, the working and living conditions of communities should be improved. Improving working conditions, providing fair pay, and promoting diversity are just some ways in which companies can contribute to the well-being of local communities. Social responsibility is not only a matter of ethics but also a way of creating a better business environment by strengthening relationships with local partners and employees.

Fourth is the impact of social responsibility on crew motivation and performance. Providing quality and variety in food that meets crews' preferences improves their job satisfaction. This increased motivation leads to higher productivity and efficiency in completing work tasks, which is critical to a marine operation's success and the company's financial sustainability.

Fifth is optimisation of procurement and resource management processes. Investing in improved sourcing and food management processes not only ensures quick and efficient access to resources but also reduces the stress and inconvenience associated with provisioning. This also leads to optimised procurement costs and improved financial performance.

Sixth is quality control and the safety of the food supplied. Quality control systems must ensure that food provided to crews is safe for consumption and meets all required standards. This not only improves crew satisfaction but also prevents health problems and accidents on board.

Transparency and accountability for social impacts are key components of companies' social sustainability. By providing clear information on social efforts and outcomes, companies can strengthen their reputation, improve crew motivation, and achieve long-term financial success. In the context of provision delivery, understanding the social organisation of onboard staff, economic pressures, industry restructuring, and the complexities of international regulation play a critical role. The factors listed can contribute to the causal chain in shipping and influence safety in the maritime industry. Understanding the importance of the financial perspective in the social sustainability of the provisioning of marine crews is important for the successful functioning of the maritime industry as a whole.

3.4.2. Social Sustainability—A Consumer Perspective

Investing in food provisions of higher quality and diversity offers significant potential for the sustainable development of maritime companies. These investments not only have the potential to improve crew health and performance but also create opportunities to optimise costs and increase operational efficiency. High-quality and diverse provisions can not only better meet crew needs but also reduce health care costs while helping to increase productivity and reduce staff turnover. In addition, these investments can help improve competitiveness by improving logistics processes and minimising supply risks. In the context of strategic management, the provision of high-quality and diverse food provisions is a key factor for sustainable growth and effective resource management in the maritime sector.

- The First Aspect Is Ensuring Access to Higher-Quality Food.

In achieving social sustainability in the provisioning of food, the primary focus should be on the consumer perspective. Providing food and beverages that meet the individual needs and preferences of crews is paramount to the physical and psychological well-being of crews. Crew members must rely on foods that are not only safe to eat but also tailored to their tastes and preferences.

First, food safety and variety must be ensured. Crew should have easy access to food and drink that meets their needs without undue restrictions or hardship. Offering a variety of food options, including special diets or dietary restrictions, can increase crew satisfaction and comfort. Variety in food is a major factor in increasing crew satisfaction and well-being, which is the basis for their higher motivation and commitment.

Second, feedback should be collected from crews. Improving the user perspective can be achieved through regular crew satisfaction ratings and surveys. Such surveys can reveal emerging issues or opportunities for improvement. In addition, providing opportunities for crew involvement in the menu and supply chain planning process will increase their engagement and satisfaction.

Third, the influence of work mode on nutritional needs should be considered. Merchant shipping is associated with significant factors that lead to sleep disruption and deprivation. Ships have non-standard working days, extensive night operations, and periods of intense effort that can lead to fatigue and stress in the crew. Prolonged periods of wakefulness and irregular work schedules can lead to reduced alertness and mood swings. This increases the risk of accidents and affects the safety of navigation. Therefore, the provision of food that is tailored to these conditions is essential for the social sustainability of provisioning.

Fourth, healthy diets and physical activity should be incorporated. In relation to improving social resilience, it is important to address nutritional principles that can support crew health. Harvard University offers the concept of a "Healthy Eating Plate" that includes guidelines for a balanced diet. Half of the diet should be made up of vegetables and fruits, a quarter from whole grains, and the other quarter from proteins such as fish, poultry, beans, and nuts. The use of healthy vegetable oils and beverages such as water, coffee, and tea is also advisable, while sugary drinks should be avoided. In addition, it is important to encourage physical activity as part of a healthy lifestyle.

Fifth, it is essential to assess the needs and preferences of crews. In order to minimise risk and enhance the social sustainability of provisioning, systematic surveys and studies should be conducted to identify the specific food preferences and cultural requirements of the crews. The findings from these surveys can be leveraged to optimise menu planning and supply chain management, ensuring that the provisioning process is aligned with the crews' needs and supports overall sustainability goals.

Sixth, a variety of provisions should be provided. Introducing a system of variety in food options, including options for special diets and dietary restrictions, can satisfy the different preferences of crews and help to keep them satisfied.

Improving the social sustainability of the provisioning of ships requires the careful management of working arrangements, onboard conditions, and the specific needs of crews. Investing in high-quality and healthy food and beverages that meet individual needs and ensure physical activity is essential to creating a sustainable and productive workspace.

- The second aspect relates to the implementation of more ethical and socially responsible practices.

Provision providers should offer food and products that are produced in compliance with social labour standards and ethical practices in the supply chain. A prerequisite for sustainability is compliance with social labour standards and ethical practices while ensuring workers' rights and safety in all stages of the production process (Mishra 2024; Benedí Lahuerta et al. 2024; Hickel et al. 2024).

First, workers' rights and safe working conditions should be respected. Suppliers of provisions must ensure that all their work processes meet international social standards. This includes providing safe and healthy working conditions, protecting workers' rights, and preventing exploitation and discrimination. For sustainability and long-term success, it is important that companies regularly inspect and certify their suppliers for compliance with these conditions.

Second, there should be ethical practices and a responsible attitude towards the environment. Suppliers must commit to environmental responsibility. This includes reducing waste, using renewable energy sources, and optimising energy efficiency in production processes. Long-term sustainability will be achieved through a commitment to minimising environmental impact while conserving natural resources.

Third, product development should be considered with social and environmental standards. In order to meet consumer demands, suppliers must include certified products that meet social and environmental standards in their product line. Certifying products to international standards will ensure their quality and ethics, creating transparency in the supply chain. This will allow companies to demonstrate their commitment to sustainability and improve their reputation.

Fourth, practices and processes should be continuously improved. Suppliers must invest in staff training and development, as well as new technology and innovation, to ensure compliance with social responsibility and sustainability standards. The application of innovation in manufacturing and supply chain logistics

can ensure that higher ethical and social standards are achieved and that production processes are optimised.

Fifth, social value and ethical practices are factors in product choice. More and more consumers are choosing products based on the social and environmental responsibility of the producer. Companies must recognise the importance of ethical and socially responsible practices and incorporate them into their supply chains to respond to these new market trends and ensure long-term business success.

These development prospects will help build sustainable and ethical supply chains while strengthening the competitiveness and reputation of companies. They will also contribute to a socially and environmentally responsible society and market.

- The third aspect relates to improving transparency and accountability for social initiatives.

Transparency and accountability in relation to social initiatives are important for the success of companies, and in some cases, these practices are mandatory under legislation, depending on the size of the business and the number of workers. Customers and stakeholders are also demanding greater clarity and openness from businesses about their social commitments and efforts to improve social responsibility. In this context, good transparency and accountability practices can strengthen consumer trust and steer them towards more sustainable brands.

First, information on social initiatives and commitments should be provided. Transparency and accountability refer to a company's clarity and openness about social initiatives, policies, and practices. Food service providers can use a variety of communication channels, such as annual reports, websites, and social media, to present their social initiatives to consumers and demonstrate their commitment to social responsibility.

Second, the impact of transparency on consumer decisions should be considered. Research shows that for many consumers, transparency and accountability are key factors in their purchasing decisions. Consumers are interested not only in the quality and price of products but also in the social and environmental responsibility of the companies from which they purchase them. This means that companies that demonstrate transparency and accountability regarding their social initiatives can attract more customers and differentiate themselves in a competitive market.

Third, brand trust should be improved through accountability. Practices to provide accountability for goal achievement can significantly improve consumer trust in a company's brand. Customers generally prefer companies that are open and honest about their social and environmental actions. Providing clear information about a company's social initiatives and achievements helps to better understand and assess its social responsibility.

Fourth, sustainable brands should be built through accountability. Good transparency and accountability practices can also help build more sustainable brands. Businesses that regularly report on their social and environmental initiatives are generally perceived as more sustainable and responsible. Not only can this increase investor interest, but it can also increase brand and company shareholder value.

Fifth, the reputation and image of an organisation can be improved. Transparency and accountability for social initiatives can strengthen a company's reputation in the eyes of the public. Businesses that openly and honestly share their social activities are often perceived as more ethical and responsible, which has a positive impact on their reputation and relationship with society.

Sixth, consumer trust is the key to successful growth. Customers increasingly demand clarity and openness about companies' social commitments. Good transparency and accountability practices improve consumers' trust and steer them towards more sustainable brands, which is essential for long-term business growth and success.

These aspects show that transparency and accountability for social initiatives play a key role in strengthening consumer trust and increasing company competitiveness.

- The fourth aspect relates to supporting community needs and values.

Commitment to community needs and values should be a core element of any logistics organisation's corporate responsibility and image. Supporting community projects and initiatives has a major impact on establishing trust and attracting consumer attention. Organisations that actively participate in community service activities demonstrate their commitment to the community, which can significantly enhance their reputation and give them an edge in the competitive environment.

First, community projects and initiatives should be engaged with. Participating in social projects and initiatives is a way for logistics companies to demonstrate their commitment to the needs of local communities. This improves a company's image and creates long-term benefits by strengthening relationships with customers and other stakeholders. This activity plays a key role in attracting new customers and retaining existing customers who value the social responsibility of businesses.

Second, reputation and competitiveness should be enhanced. Supporting community needs and values can bring significant benefits in a competitive environment. Organisations that actively demonstrate social responsibility are perceived as more trustworthy and ethical than their competitors. This can give them an advantage in the marketplace and strengthen their reputation, thereby contributing to the long-term success of the businesses.

Third, there should be a commitment to sustainability and sustainable business practices. Increasingly, customers prefer suppliers that actively support communities and work towards sustainable supply chain goals. This commitment can strengthen the relationship between an organisation and its partners, including shipowners and managers. As a result, they will be more interested in the products and services of a company that is committed to social and environmental goals.

Fourth, there are long-term benefits of proactive participation in social activities. Proactive engagement with community needs and values also strengthens the long-term sustainability of a company. This engagement not only improves public perception but also creates lasting relationships with customers and partners who value social responsibility.

Organisations' engagement with community needs and values not only enhances their reputation but is also an important element for sustainable growth and success in a competitive marketplace.

3.4.3. A Process Perspective on Social Sustainability

- The first aspect is effective supply chain management.

It is now established that choosing the right supplier is paramount to developing sustainable partnerships in the supply chain for marine food provisions. Achieving this goal requires special attention to environmental, social, and economic aspects in the selection of suppliers to ensure sustainability throughout the supply chain. The supplier selection process requires a detailed assessment of supplier performance, taking into account multiple objectives and criteria, one of which should be related to sustainability and environmental criteria.

First, appropriate supplier assessment methods and practices should be implemented. Selecting suppliers requires a flexible approach that prioritises multiple decision criteria, including environmental and social aspects. These criteria need to be supported by a variety of decision-support methods and tools, taking into account the growing concern for environmental issues.

Second, there should be green supply chain management. In an environment of growing global awareness of environmental issues, the management of environmental aspects in the supply chain is becoming increasingly important. Supplier assessment should include both their basic and advanced environmental practices. This includes collaborative environmental product design and environmental measures.

Third, risk management and social aspects should be considered. Effective supply chain management involves controlling and monitoring social aspects in all phases of the process. In order to ensure effective risk management, it is necessary to develop measures to protect workers' rights and prevent labour exploitation (Sugiyama et al. 2024). In this regard, it is important to establish strict standards for suppliers to ensure that workers' rights are respected and that fair and safe working conditions are provided.

Fourth, suppliers should be regularly monitored and audited. Ensuring effective oversight of social responsibility requires regular supplier audits by qualified sustainability and social responsibility auditors. The audits should document evidence of the correct application of standards and assurance that they comply with international social responsibility requirements.

Fifth, supplier collaboration and training should be considered. Active collaboration with suppliers is needed to improve practices and working conditions. This includes providing training and resources to improve work practices, as well as developing innovations to manage risk more effectively. Dialogue with suppliers is essential to achieve better conditions and reduce risks in the process of sourcing food provisions.

Sixth, there should be a holistic approach to supply chain management. Effective supply chain management for seagoing ships requires a holistic approach that includes not only the control and monitoring of social aspects but also the implementation of risk management measures related to labour exploitation and violations of workers' rights. This ensures sustainability and social responsibility throughout all phases of the provisioning supply chain.

The practices and measures presented only set the basic guidelines for ensuring effective supply chain management, which will lead to better social sustainability and reduced risks in the process of procuring food provisions for seagoing vessels.

In addition to these measures, dialogue and cooperation with suppliers should be encouraged to provide support and training on social responsibility and risk management. The provision of training and resources can improve working practices and working conditions, and active collaboration can develop more effective and innovative risk management solutions.

- The second aspect is to improve working conditions.

Achieving social sustainability is inextricably linked to processes of improving working conditions for supply chain workers. This requires compliance with already established social labour standards and taking appropriate measures to ensure safety and good working conditions for all involved in the processes. Transparency and accountability play a key role in providing clarity and information for all stakeholders.

First, they should enforce social standards and protect workers' rights. To achieve social sustainability in the supply chain, organisations must take concrete steps to improve working conditions, protect workers' rights, and ensure equal access to professional development opportunities. This includes putting in place policies and procedures to ensure safe and healthy working conditions.

Second, training and development should be provided for workers. A key part of the process of improving working conditions is providing training and development opportunities for workers. These initiatives will not only improve employees' professional skills but also increase their motivation and job satisfaction, which is important for social sustainability.

Third, data on working conditions must be collected and analysed. Organisations should collect and analyse data on the social practices and working conditions of their suppliers. This allows for the assessment of progress in improving working conditions and the identification of areas for improvement. Data can include information on workplace safety, health conditions, and equality in opportunity for progression. Fourth, there should be transparency and accountability. It is important for organisations to provide information and transparency in their efforts to improve social sustainability throughout the supply chain. The practice of publishing annual sustainability reports is a good way to document progress in improving working conditions, and these reports can be the basis for active participation in social accountability and certification initiatives.

Fifth, a fair and sustainable supply chain should be created. By implementing appropriate policies and measures to ensure safety and good working conditions for workers and by providing transparency and awareness to all stakeholders, organisations supplying food provisions to seagoing crews can contribute to achieving a more equitable and sustainable supply chain.

The measures and practices listed could help create better working conditions and ensure that provisioning processes not only meet social and environmental standards but also contribute to the long-term sustainability of the business.

3.4.4. Perspective for Learning and Development

- Reducing discriminatory provisions.

The factors that have the greatest impact on achieving social sustainability are undoubtedly related to reducing discriminatory provisions and promoting equity in the recruitment, training, and retention of a skilled workforce. This is essential for the effective functioning of the food supply chain, ensuring the smooth provision of necessary inputs and regular supplies.

First, discriminatory practices should be eliminated. In order to achieve social sustainability, it is important to eliminate all forms of discrimination in the recruitment, training, and retention of the workforce. This means ensuring equal access to employment and professional development opportunities for all crew members, regardless of their gender, race, age, religion, or other personal characteristics. Eliminating discrimination is the basis for creating a fairer work environment.

Second, equality should be promoted. Promoting equality in the choice of personnel and their opportunities for advancement is a key element in achieving better social sustainability. Diversity in teams and ensuring non-discriminatory practices create a fairer and more socially responsible workplace. This not only improves the working environment but also helps to increase the motivation and productivity of crews.

Third, motivation and productivity can be increased. Workplaces that promote equality and eliminate discriminatory practices increase employee motivation. When crews feel respected and equal, they are more engaged and motivated to perform their duties with a high degree of responsibility and efficiency, leading to better business outcomes.

Fourth, there are long-term benefits of a socially responsible workplace. Ensuring equity in recruitment and development processes creates stable and effective working relationships that will lead to sustainable and successful business practices in the long term. This is essential to achieving social sustainability throughout the supply chain.

Reducing discriminatory regulations and promoting equity is not only ethical but also strategically important to creating an efficient and productive work environment, which is key to achieving social sustainability in the food supply chain.

- Socially responsible staff training and education.

Crew training and skill development play a key role in enhancing the efficiency and safety of maritime operations. The provision of training not only enhances the knowledge and skills of workers but also increases their professional competence and confidence in carrying out their duties. In order to achieve social sustainability, it is essential to offer training programmes tailored to the maritime industry's specific needs and requirements.

First and foremost, providing high-quality training that aligns with the specific needs of the maritime industry is essential. In order to ensure the training's effectiveness, it must be tailored to address the real and current demands of the maritime sector. This includes developing educational programmes that not only

enrich the knowledge of crews but also improve their practical skills in the context of the safety and efficiency of maritime operations.

Second, qualified staff should be retained. One important aspect of social sustainability is the retention of already skilled and trained personnel who can contribute to the stability and continuity of the operations of seagoing ships. Staff retention is achieved by creating stimulating working conditions and career development opportunities, as well as offering social benefits that motivate the crew to be committed and dedicated to their jobs.

Third, a stable and supportive work environment should be created. Establishing work–life balance policies and practices, as well as recognition of workers' achievements, plays an important role in ensuring a stable work environment. These efforts not only improve crew motivation but also increase their productivity and job satisfaction while promoting social sustainability.

Fourth, investment should be made in the recruitment, training, and retention of skilled staff. Investment in the recruitment, training, and retention of skilled personnel is vital to the sustainable development of the seagoing crew food supply chain. Well-trained and motivated crew members play a critical role in ensuring quality and regular deliveries, which are the basis for the safety of maritime operations and the continuity of logistics processes.

Fifth, the competitiveness of maritime operators should be enhanced. Social sustainability not only enhances the competitiveness of maritime operators but also ensures the continuity of supply and the safety of maritime operations. Investing in qualified staff's skills and motivation creates a stable and sustainable business development base, which is key to the successful operation of the industry.

Staff training and development in the maritime industry is fundamental to achieving social sustainability. They not only provide the necessary professional competence but also create motivated and committed teams that contribute to the supply chain's long-term success and maritime operations' safety.

- Cooperation with educational institutions and NGOs.

In the framework of social strategy in food supply chains, collaboration with educational institutions and NGOs that support educational and social initiatives plays an important role in achieving sustainable development. This collaboration can foster the exchange of knowledge and skills, as well as contribute to a better future for the communities in which activity takes place.

First, there should be curriculum development. Collaboration with educational institutions can be achieved by developing curricula that emphasise sustainable food sourcing and consumption. Such programmes could include theoretical and practical sessions on sustainable supply chain management, as well as training on socially responsible practices in the selection and storage of food provisions.

Second, trainings and seminars should be organised. Another way to collaborate is to organise training and seminars for both crew members and everyone involved in the delivery process. Such initiatives could include learning about various sustainable practices, such as choosing food products with a minimal environmental footprint, as well as provisioning approaches that reduce waste and wastage.

Third, innovative sourcing solutions should be integrated. An existing opportunity for collaboration between business and educational institutions is the integration of innovative sourcing solutions that are both environmentally friendly and socially responsible. This could include solutions to optimise supply chains, reduce the carbon footprint in the environment, and support local communities through better supply planning and reduced energy costs.

Fourth, joint programmes and projects should be implemented. Joint programmes and specific projects to introduce new methods of sustainable sourcing can lead to practical solutions that can be implemented in real shipboard conditions. Such projects could include the implementation of sustainable technologies and supply chain management methods to ensure the more efficient use of resources and minimisation of waste.

Through these initiatives, collaboration with educational institutions and NGOs can contribute to achieving socially responsible and sustainable practices throughout the supply chain of food provisions for marine crews. This will encourage a greater commitment to environmental protection and social responsibility while ensuring a better future for the communities and industries involved in these processes.

3.5. Conclusions of Chapter Three

Chapter Three of this study focuses on social sustainability in the provisioning of seagoing ship crews. The practices of provisioning and onboard feeding are analysed. This chapter focuses on social sustainability in onboard provisioning by considering the following main perspectives: financial, consumer, process, and learning and development perspectives.

Within the financial perspective, the importance of ensuring healthy and safe working conditions for ship crews is discussed. The financial resources allocated to this purpose are found to help achieve social sustainability on board by improving the working environment and providing adequate compensation for crews.

The consumer perspective of social sustainability is related to provision quality, accessibility, and diversity. It is found that healthy and varied diets positively impact crew satisfaction and motivation, helping to improve physical and psychological comfort.

The process perspective focuses on effective inventory management and quality control of provisions. It is found that quality control and monitoring systems can increase confidence in food resources and improve crew satisfaction.

Social skill development, stress management, and support for healthy living on board are considered from a training and development perspective. It is found that social programmes and projects can improve team cooperation, reduce stress, and promote healthy habits among crews.

This chapter concludes by presenting a comprehensive approach to ensuring social sustainability in the provisioning of ships, highlighting the importance of financial, consumer, process, and educational aspects in this area.

4. Environmental Sustainability Aspect

Chapter Four discusses opportunities for environmental sustainability improvements in the context of provisioning for seagoing ships. It explores how financial, consumer, process, and educational aspects can be integrated to achieve more environmentally sustainable practices in supply chains. The financial perspective highlights the importance of investing in sustainable practices through the use of alternative energy sources and supplier diversification, which can reduce operational costs and environmental impacts. The consumer perspective focuses on increasing environmental awareness and ensuring transparency and accountability to improve customer trust and satisfaction. The process perspective looks at how effective waste management and logistics optimisation can help reduce emissions and improve energy efficiency. The educational perspective focuses on the importance of training for environmentally friendly practices and support for innovation and research that can help develop more sustainable food production, transport, and storage methods. Chapter Four presents a comprehensive framework for implementing environmentally sustainable practices in food provisioning on marine vessels that can contribute to minimising environmental risks and improving the sustainability of marine supply chains.

4.1. Introduction to Environmental Development Perspectives

The introduction of environmentally sustainable practices appropriate to the conditions when providing food provisions for merchant ships can have a beneficial impact on reducing harmful environmental impacts. The introduction of such practices requires, in the first instance, a detailed review to identify the main sources of pollution and waste. An essential part of the review should cover analysing and assessing GHG emissions associated with transport and provision logistics. According to a report by Azhar et al. published in 2024, the transport sector continues to be a major source of greenhouse gas emissions in the European Union, with road transport accounting for the most significant part of these emissions (Azhar et al. 2024).

Research shows that the energy efficiency of vehicles is closely linked to their type, age, and propulsion technology. For example, electric vehicles have significantly lower emission levels than traditional internal combustion vehicles, especially when charged with renewable energy (Stevic 2012; Chi 2025). Identifying the main sources of carbon emissions can help develop strategies to reduce them, such as optimising routes and using more environmentally friendly means of transport. In this context, some logistics operators have already introduced the use of hybrid or electric vehicles to deliver provisions, which significantly reduces carbon emissions.

Another important part of the analysis should focus on the reduction in packaging materials used by assessing the quantities and types of materials used to package food provisions and considering their biodegradability and recyclability (Hussain et al. 2024; Kesgin et al. 2025) Legacy Matters. Specific good practices in this area include using packaging made from biodegradable materials such as corn starch or recycled paper and implementing reusable container systems.

In addition to an analysis of packaging materials used, there is also a need to focus on minimising and properly managing the waste generated by activities (Manzoor et al. 2024). There is also a need to review current methods of waste collection, storage, and handling, as well as looking at ways to reduce and use it efficiently. Some of the good practices already in place relate to composting or waste treatment, which not only help to reduce waste but can also provide additional sources of energy. Other good practices can be added to these basic aspects to improve environmental sustainability further. For example, some operators have started using local and seasonal products to reduce the need for long transport distances and, therefore, carbon dioxide emissions. Another good practice is the introduction of energy-efficient appliances for food storage and preparation, which in turn also contributes to reducing energy costs and footprint.

Performing a detailed review of the mentioned aspects in the initial analysis can provide the necessary information to identify the main problem areas and opportunities for improvement in the environmental sustainability of the provisioning of marine vessels. The analysis can serve as a basis for developing effective strategies and measures to reduce the environmental footprint and improve the sustainability of maritime operations. Adopting and implementing the above best practices demonstrates companies' commitment to sustainable development and protecting the marine environment.

4.2. Study Methodology for Environmental Sustainability

4.2.1. The Objective of the Study

This study on the maritime industry's environmental aspects of food provisioning aims to analyse crew perceptions of the environmental impacts of onboard food provisioning activities and assess their willingness to support food waste reduction initiatives. The main objective is to improve the management of food stocks and reduce the environmental footprint while ensuring sustainable and efficient shipboard operations.

At the heart of this study is the hypothesis that environmental sustainability can be significantly improved by actively engaging crew in environmental practices and waste reduction, which will lead to positive environmental and social outcomes.

The same participants who were surveyed in the previous studies detailed in Chapters Two and Three participated in this study to identify how the crew perceive environmental practices for managing food provisions and how these perceptions relate to their support for food waste reduction initiatives. The surveys and interviews conducted with participants helped to establish their level of awareness of the environmental implications of shipboard activities and how these factors influence their behaviours and practices.

The thesis of this study is that there is a statistically significant correlation between crew perceptions of the environmental consequences of food provisioning activities and their practices and support for food waste reduction initiatives. This highlights the importance of crew awareness and commitment to environmental practices for better crew health and ship sustainability.

Null Hypothesis (H_0): There is no statistically significant correlation between crew perceptions of the importance of the environmental consequences of food provisioning activities and their current practices and support for food waste reduction initiatives, and accordingly, the coordinates in the correlation matrix are not significantly different from 0 at a significance level of alpha = 0.05.

Acceptable Hypothesis (H_1): There is a statistically significant correlation between crew perceptions of the importance of the environmental consequences of food provisioning activities and their current practices and support for food waste reduction initiatives. This translates to a significance (p-value) of less than 0.05, indicating a strong correlation between these variables.

4.2.2. Participants in the Study

The survey, conducted in the context of the environmental sustainability of the supply of food provisions on board seagoing ships, involved the same 98 respondents who participated in the previous surveys described in the preceding chapters. These participants included managers, logistics company executives, business owners, logistics and supply chain management specialists, and employees responsible for inventory management and food supply. The choice of the same participants for this study was justified by the need to ensure consistency in the sample and to conduct a comparative analysis of the data across the different stages of the study. By including the same group of respondents, it was possible to observe changes in their perceptions and practices more deeply (Thomas 2022; Frey 2018; Fleetwood 2018) related to environmental sustainability, allowing for a more accurate and in-depth exploration of the factors that influence their attitudes towards sustainable food waste reduction initiatives.

The participants were selected in a way that ensured that they all have sufficient experience and knowledge in logistics, food stock management, and sustainable sourcing. They are directly involved in food procurement and provision management activities, making them particularly well suited to explore their perceptions of the environmental impacts of these activities. In addition, these actors possess knowledge and competencies that are important for evaluating environmental initiatives, as their work requires implementing solutions that meet performance and sustainability standards.

Using the same group of participants provides a longitudinal approach to analysing changes in their behaviour and perceptions (Ryan 2006), which is important for better understanding the social and environmental aspects of sustainability in the context of the marine industry. This allows valid inferences to be made about their commitment to sustainable practices and to identify changes in their attitudes and behaviours related to environmental sustainability.

4.2.3. Data Collection Method

The data collection method in this study was based on the use of a specially designed questionnaire that focused on the environmental aspects of crew perceptions of the effects of food provisioning activities on board the ship. The questionnaire was designed to assess crew perceptions of the environmental

consequences of their work, as well as to provide information on possible initiatives and practices to reduce the environmental footprint of food provisioning.

Participants in the survey were instructed in advance to mark the answer they considered correct by placing an "X" in the appropriate box. This response methodology was chosen to provide an easy-to-complete and standardised format to minimise potential errors or misunderstandings. The questionnaire was printed on paper, which was driven by the limited access crew have to electronic devices with the internet, especially in a maritime environment.

Paper questionnaires were distributed in person to each crew member or through a research team representative, which provided direct communication with participants and ensured a full understanding of the study objectives. The questionnaires were distributed during training sessions, meetings, or other planned events, which provided convenient conditions for completing the questionnaires without disrupting the crew's workflow. This method was chosen because it provided easy access to participants while ensuring the confidentiality of the information collected and ensuring high data quality.

4.2.4. Data Analysis Method

The data collected through the questionnaire were processed and analysed to extract key findings and trends related to the crew's environmental practices regarding the management of food provisions. The questionnaire contained five main questions that assessed the importance of preventing the disposal of edible food, reducing food waste, and taking measures to manage it. These questions focused on the importance of sustainable waste reduction practices and their effective management, which is essential to achieve environmental sustainability in the maritime industry.

The data were analysed as aggregated information, with individual participant identifiers removed to ensure anonymity. This ensured participant confidentiality and made the results more reliable. Descriptive statistics were used to summarise the main features of the data, allowing the main trends in responses to be analysed and to identify how different factors influence crew perceptions of the environmental aspects of food provisions.

In order to establish the relationships between different aspects of crew perceptions and their readiness to implement sustainable practices, correlation analysis was used. The Spearman correlation coefficient, calculated using the XLSTAT software package (Addinsoft 2024), provides information on the strength and direction of the relationships between different environmental aspects of food provisions and crew satisfaction levels.

The results obtained on crew preferences and attitudes about environmental practices related to food provision management provide valuable guidance for future efforts to improve onboard food provision management processes. These results will inform the design and development of environmental sustainability optimisation measures that address crew needs and preferences while reducing the environmental footprint of shipping.

4.2.5. Survey Questionnaire Environmental Aspect

The questionnaire aimed to explore crew attitudes towards the environmental consequences of food provisioning activities on board ships. The survey focused on perceptions of the importance of preventing the disposal of edible food, reducing food waste, and taking measures to manage it effectively.

Table 9 presents the crew attitude questionnaire, which assessed their perceptions of the importance of the environmental consequences of food provisioning activities on board ships.

Table 9. The questionnaire for the environmental survey.

Answers	**Questions**
1: Not relevant 2: Little Importance 3: Average 4: Great importance 5: Huge	Q1. How would you rate the importance of preventing the disposal of edible food for various reasons (e.g., excess, inadequately prepared, not consumed due to intolerance or bad taste, etc.)?
1: Not relevant 2: Little Importance 3: Average 4: Great importance 5: Huge importance	Q2. How would you rate the importance of reducing edible food waste in your work environment?
1: Not relevant 2: Little Importance 3: Average 4: Great importance 5: Huge Importance	Q3. How would you rate the importance of taking measures to reduce food waste in your work environment?
1: We have not established a specific practice 2: Disposal in waste containers 3: Partial recycling and disposal 4: Application of processing or finishing practices 5: Recycle, reprocess or process as appropriate	Q4. What is your current practice for handling food that remains unconsumed but is fit for consumption?
1: Minor support 2: Little support 3: Moderate support 4: Great support 5: Very great support	Q5. Please give an overall assessment of your support for food waste reduction initiatives

Table 9. *Cont.*

Importance of short answers to question 5 Marginal support: Participants expressed very little or no support for food waste reduction initiatives. This may indicate that they do not consider such initiatives important or are not interested in them. Little support: the participant expressed little support for food waste reduction initiatives but did not think they mattered much or did not care much about the issue. Moderate support: the participant expressed moderate support for food waste reduction initiatives. He may believe that these initiatives are important but perhaps not high on his priorities. Strong support: participant expresses strong support for food waste reduction initiatives. He considers them important and can support such initiatives with participation or cooperation. Very much support: the participant expresses maximum support for food waste reduction initiatives. He considers them extremely important and may be willing to support and actively participate in such initiatives.

Source: Table by author.

4.3. Results of the Survey

The questionnaire completed by 98 respondents showed that all questions were answered with no missing data, ensuring the completeness of the analysis.

4.3.1. Summary Statistics

The minimum response values ranged between 2 and 3 (Table 10), while the maximum values were equal to 5 for all questions, suggesting that participants generally attached high importance to all aspects considered.

Table 10. Summary statistics (quantitative data).

Variable	Observations	Minimum	Maximum	Mean	Std. Deviation
Q1	98	3000	5000	4357	0.677
Q2	98	3000	5000	4551	0.540
Q3	98	3000	5000	4480	0.646
Q4	98	2000	5000	4071	0.840
Q5	98	3000	5000	4337	0.673

Source: Table by author.

The mean scores for all questions are above 4, indicating that the crew highly value the importance of preventing food waste, reducing it, and taking measures to manage it. The highest mean is for question Q2 (4.551), which highlights the importance of reducing edible food waste in the work environment.

4.3.2. Correlation Matrix

The correlation analysis conducted on the questionnaire data revealed significant relationships between the different variables assessing the importance of

environmental practices related to food provisions on board ships. The correlation matrix in Table 11. presents the relationships between the different questionnaire variables, assessing the importance of preventing the disposal of edible food, reducing food waste, and taking measures to manage it effectively. The values in the matrix indicate the degree of correlation between these variables, with higher values indicating stronger relationships.

Table 11. Correlation matrix.

Variables	Q1	Q2	Q3	Q4	Q5	3	4	5
Q1	1	0.528	0.547	0.571	0.887	−0.524	−0.530	0.861
Q2	0.528	1	0.831	0.458	0.534	−0.305	−0.333	0.526
Q3	0.547	0.831	1	0.506	0.574	−0.366	−0.308	0.540
Q4	0.571	0.458	0.506	1	0.650	−0.456	−0.297	0.585
Q5	0.887	0.534	0.574	0.650	1	−0.710	−0.445	0.895
3	−0.524	−0.305	−0.366	−0.456	−0.710	1	−0.314	−0.321
4	−0.530	−0.333	−0.308	−0.297	−0.445	−0.314	1	−0.798
5	0.861	0.526	0.540	0.585	0.895	−0.321	−0.798	1

Source: Table by author.

The results show a strong positive correlation (r = 0.887) between ratings of the importance of preventing edible food waste (Q1) and overall support for food waste reduction initiatives (Q5). The result suggests that participants who place high importance on preventing food waste are also likely to actively support initiatives aimed at reducing food waste. This relationship highlights the crew's perceptions' consistency and willingness to participate in environmental initiatives.

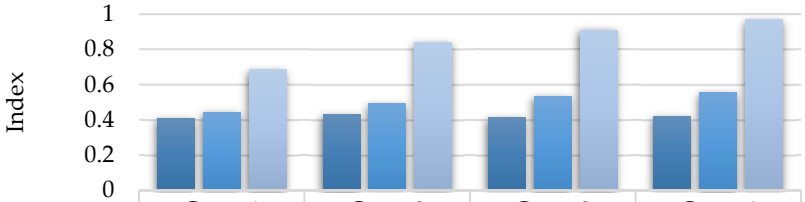
A strong positive relationship (r = 0.831) is also found between the importance of reducing edible food waste in the work environment (Q2) and the importance of taking measures to reduce food waste (Q3). This result suggests that the crew who attach high importance to reducing food waste also consider it important to take active measures to manage this waste. This alignment between importance ratings and action-taking is key to the successful implementation of environmental practices. The assessment of current practices for handling non-consumable but usable food (Q4) also shows a significant positive relationship (r = 0.650) with support for food waste reduction initiatives (Q5). This suggests that crew already implementing effective food inventory management practices are also likely to support additional initiatives in this regard. Such support is important for the sustainable management of resources on board.

Negative correlations found in the analysis reveal areas of inconsistency or differences in crew perceptions. For example, a moderately negative correlation ($r = -0.524$) between ratings of the importance of preventing food waste (Q1) and certain other aspects, represented as $V3$, may indicate different priorities or perceptions among participants. The most significant negative correlation ($r = -0.710$) is between support for waste reduction initiatives (Q5) and $V3$, indicating that participants who actively support these initiatives may have opposing views on other specific practices. This correlation suggests that there may be a group of participants who, while supporting the idea of waste reduction, disagree with specific approaches or practices that are being used to achieve these goals.

The results of the correlation analysis deepen the understanding of crew attitudes and behaviours regarding environmental practices on board ships. High positive correlations indicate consistency in attitudes and crew willingness to support food waste reduction initiatives. Negative correlations, on the other hand, reveal areas that require additional attention and effort to bridge perception gaps. These results can be used to develop more effective strategies and programmes to improve sustainable food management and increase overall environmental awareness and crew engagement.

4.3.3. Interpretation of Model Quality

Figure 6 presents various statistical indicators to assess the quality of the model used in this study. The Q^2 cum, R^2Y cum, and R^2X cum metrics were calculated for four components (Comp1, Comp2, Comp3, and Comp4), which allowed an assessment of the interpretative and explanatory power of the model.



	Comp1	Comp2	Comp3	Comp4
Q^2 cum	0.409	0.433	0.413	0.421
R^2Y cum	0.441	0.493	0.531	0.557
R^2X cum	0.684	0.841	0.909	0.968

Components

Figure 6. Model quality by number of components. Source: Figure by author.

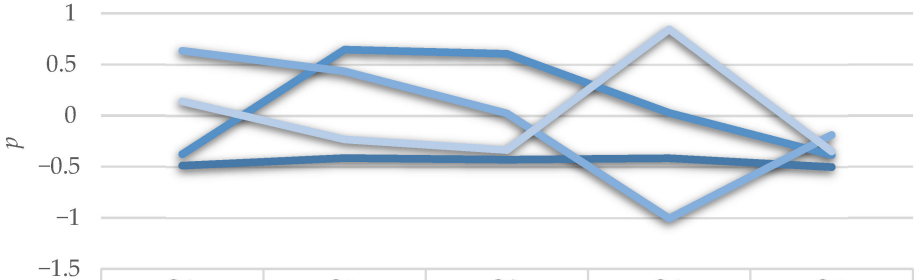
Cumulative interpretability (Q^2 cum) indicates how effectively the model can interpret new data. The Q^2 cum values for all components exceed 0.4, which is an indicator of good interpretability. Especially for the second component (Comp2), Q^2 cum reaches 0.433, which defines it as the best in terms of its interpretability among all components.

The coefficient of determination for the dependent variable (R^2Y cum) illustrates the proportion of the variance of the dependent variable that the model explains. The R^2Y cum values show an increase from 0.441 for Comp1 to 0.557 for Comp4. This increase demonstrates that as more components are added, the model improves its ability to explain the variation in the dependent variable, with the last component contributing the most to this explanation. The coefficient of determination for the independent variable (R^2X cum) reflects the extent to which the model can explain the variation in the independent variable. The R^2X values range from 0.684 for Comp1 to 0.968 for Comp4, indicating the very good explanatory power of the model. This trend of increasing R^2X as more components are added highlights that the model becomes more effective in explaining variation in the independent variables.

The presented analysis of model quality shows that it has high interpretative and explanatory power. The values of Q^2 and R^2Y demonstrate that the model effectively interprets and explains variation in the dependent variable, while the high values of R^2X confirm the strong explanatory power for the independent variables. The addition of more components to the model leads to an improvement in both interpretative and explanatory power, which is evident from the increasing values of all key indicators.

4.3.4. Interpretation of p Vectors

The figure with p vectors presents the results of the factor analysis, which reveal the principal components ($p1$, $p2$, $p3$, $p4$) and their impact on the different variables (Figure 7). The interpretation of these vectors provides a deeper understanding of the factors that influence different aspects of perceptions of food provisions on board ships.



	Q1.	Q2.	Q3.	Q4.	Q5.
$p1$	−0.490	−0.415	−0.431	−0.417	−0.504
$p2$	−0.379	0.645	0.605	0.026	−0.386
$p3$	0.635	0.432	0.020	−1.007	−0.189
$p4$	0.139	−0.233	−0.337	0.845	−0.350

Explanatory variables

Figure 7. The p vectors. Source: Figure by author.

The first variable (Q1), which examines the importance of preventing the disposal of edible food, shows that the third component ($p3$) has the largest positive influence with a value of 0.635. This means that this component is associated with a strong evaluation of the importance of preventing food waste. The negative values for the first ($p1$) and second ($p2$) components suggest that these components have an inverse relationship with this evaluation.

The second variable (Q2), which assesses the importance of reducing the disposal of edible food in the work environment, is most strongly associated with the second component ($p2$), which has a value of 0.645. This indicates that this component plays an important role in assessing the importance of reducing food waste in the work environment. A positive value for the third component ($p3$) also indicates a significant relationship, while negative values for the first and fourth components suggest a weaker or inverse relationship.

The third variable (Q3), related to the assessment of the importance of taking measures to reduce food waste in the work environment, is most strongly related to the second component ($p2$), with a value of 0.605. This highlights the importance of this component in the context of food waste reduction measures. Component $p3$ has a non-significant value (0.020), indicating that it has no significant influence on this assessment, while $p1$ and $p4$ have negative values, indicating a weaker or inversely proportional influence.

The fourth variable (Q4), which looks at current handling practices for non-consumed but usable food, shows a strong negative relationship with the third component ($p3$) with a value of -1.007 and a strong positive relationship with the fourth component ($p4$) with a value of 0.845. This suggests that the third component is associated with a negative perception of current practices, while the fourth component is associated with a positive perception. The values for the first and second components are close to zero, indicating less influence.

The fifth variable (Q5), which provides an overall assessment of support for food waste reduction initiatives, has negative values for all components, with the first component ($p1$) having the largest negative impact with a value of -0.504. This indicates that support for food waste reduction initiatives has an inverse relationship with all four components, with the first component having the strongest inverse relationship.

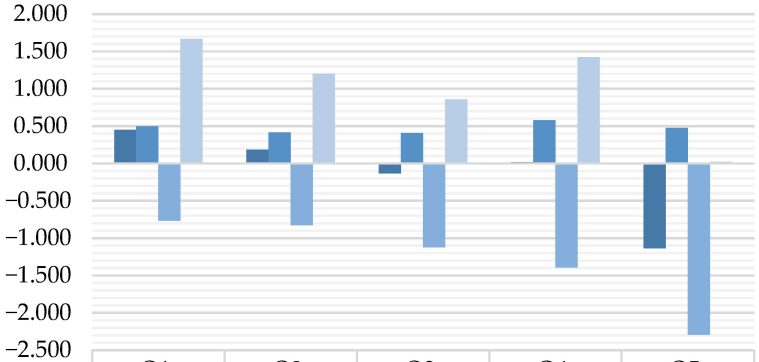
The interpretation of these results reveals the complex structure of the relationships between the different components and estimates of the importance of environmental practices related to food provisions on board ships. Components $p2$ and $p3$ have a significant positive influence on estimates of food waste reduction and action taken, while component $p4$ is strongly associated with current practices for handling non-consumed food. Negative values for component $p1$ indicate that it has an inverse relationship with support for environmental initiatives.

The results highlight the need for further research into the specific factors influencing crew perceptions and their willingness to support and implement environmental practices. They also provide valuable information for the development of strategies to improve food inventory management and reduce food waste on board ships.

4.3.5. Interpretation of Standardised Coefficients

In Figure 8, the standardised coefficients (95% conf. interval) show the impact of different variables on the overall support score for food waste reduction initiatives. The coefficients are presented with their standard deviations and 95% confidence intervals.

The first variable (Q1), which looks at the importance of preventing the disposal of edible food for various reasons, has a positive standardised coefficient of 0.448 with a standard deviation of 0.497. The result indicates that this variable has a moderately positive impact on overall support for food waste reduction initiatives. However, the confidence interval ranges from -0.768 to 1.665, revealing that this effect may not be statistically significant as the interval includes zero.



	Q1.	Q2.	Q3.	Q4.	Q5.
Coefficient	0.448	0.185	−0.135	0.014	−1.136
Std. deviation	0.497	0.415	0.405	0.576	0.473
Lower bound (95%)	−0.768	−0.830	−1.126	−1.394	−2.294
Upper bound (95%)	1.665	1.200	0.856	1.422	0.021

Figure 8. Standardised coefficients (95% conf. interval). Source: Figure by author.

The second variable (Q2), which assesses the importance of reducing food waste in the work environment, has a positive standardised coefficient of 0.185 with a standard deviation of 0.415. The confidence interval (−0.830 to 1.200) also indicates that this coefficient is not statistically significant and does not significantly affect the overall support for the initiatives.

The third variable (Q3), related to the importance of taking measures to reduce food waste in the work environment, has a negative standardised coefficient of −0.135 with a standard deviation of 0.405. The confidence interval (−1.126 to 0.856) again indicates that this coefficient is not statistically significant and has no significant impact.

The fourth variable (Q4), which looks at the current practice of managing uneaten but usable food, has a very small positive standardised coefficient of 0.014 with a standard deviation of 0.576. The confidence interval (−1.394 to 1.422) is wide and includes zero, clearly indicating the lack of statistical significance.

The fifth variable (Q5), which represents the overall assessment of support for food waste reduction initiatives, has a significant negative standardised coefficient of −1.136 with a standard deviation of 0.473. The confidence interval (−2.294 to −0.021) is negative and entirely below zero, highlighting the statistical significance of this coefficient. This implies that lower support scores for food waste reduction initiatives have a strong negative impact on the perception of questionnaire respondents about these initiatives.

An analysis of the standardised coefficients shows that although some variables, such as the importance of preventing the disposal of edible food (Q1), have a moderate positive impact, they are not statistically significant. The most significant impact is observed for the variable Q5, which reflects the overall assessment of support for food waste reduction initiatives. The variable has a strong negative effect, suggesting that a lack of support for such initiatives significantly undermines the

perception of their importance. These results are important for developing strategies to improve support for food waste reduction initiatives, focusing on improving employee perception and engagement in these processes.

The analysis of the survey results provides important information that can be used as a basis for the development of a Balanced Scorecard (SBSC) for the environmental aspect of food provision sustainability. This implies that their effect on environmental sustainability is limited and does not significantly affect the final results.

On the other hand, the variable Q5, which measures overall support for food waste reduction initiatives, stands out as having a strong negative effect. This indicates that when there is a lack of support for such initiatives, the perception of their importance deteriorates significantly. This result is key to developing effective strategies aimed at increasing employee support and commitment to environmental initiatives.

In the context of the SBSC, these data can be used to formulate specific indicators and targets to guide organisations towards improving environmental sustainability through food waste reduction. For example, by focusing on raising awareness and support for food waste reduction initiatives, greater employee participation can be stimulated, and better environmental outcomes can be achieved.

The analyses were used to develop the SBSC as they provide a basis for creating measures and indicators that reflect and support the environmental sustainability of food provisions over the long term.

4.4. SBSC—Environmental Sustainability of Ship Provisions

In modern environmental sustainability research, particularly in the context of provisioning on board seagoing ships, it is essential to apply integrated assessment methods that cover different aspects of sustainability. Table 12 presents a Balanced Scorecard (SBSC) that covers four main perspectives: financial, consumer, process, and learning and development perspectives. These perspectives will be analysed in detail in the subsequent presentation, the aim being to provide a holistic approach to assessing and improving sustainability in ship provisioning.

The financial perspective focuses on opportunities for cost optimisation through investment in sustainable technologies and practices, such as the use of renewable energy sources and supplier diversification. This not only reduces the negative impact on the environment but also improves the cost-effectiveness of processes.

The consumer perspective in the SBSC highlights the importance of transparency and environmental awareness to customers. Implementing sustainable practices in the supply chain and providing information about them can increase consumer trust and satisfaction. This encourages them to choose more sustainable options and support green initiatives.

The process perspective looks at the stages of effective waste management, logistics optimisation, and energy efficiency improvement, which are key to reducing emissions and improving supply chain sustainability. Significant reductions in environmental impact are achieved by streamlining processes and optimising transport distances.

The training and development perspective emphasises the need for professional crew training on environmental practices as well as support for innovation and research. These initiatives are key to developing new solutions that reduce environmental pressures and improve the sustainability of supply chains.

Table 12. Environmental sustainability in provisioning.

4.4.1. Financial Environmental Sustainability Perspective	**4.4.2. User Perspective on Environmental Sustainability**	**4.4.3. Process Perspective on Environmental Sustainability**	**4.4.4. Perspective of Learning and Development on Environmental Sustainability**
- Investing in sustainable practices - Achieving economies of scale - Savings on the size and type of transport used - The optimisation of storage space - Supplier diversification	- Educating and informing consumers - Sourcing sustainable food materials - Supporting local suppliers and long-term partnerships - Leveraging technology and innovation	- The optimisation of transport processes - The optimisation of procurement processes - Optimising transport flows and logistics - Packaging process optimisation - Sustainable packaging practices	- Training for effective environmental sustainability management - The development of environmental culture on board - Ways to motivate and involve crew - The role of management innovation and research in environmental sustainability

Source: Table by author.

4.4.1. Financial Perspective on Environmental Sustainability

- First aspect: Investing in sustainable practices.

Investment in sustainable practices is a necessary but insufficient condition for the successful realisation of environmental sustainability in the provisioning of marine vessels (Wang et al. 2020; Choi et al. 2016). The reason for this is that most environmental practices require initially larger investments that have the potential to positively affect the long-term financial performance of ships (Halff et al. 2019). Examples of best practices that contribute to reduced operating costs can be related to investing in energy-efficient technologies, using energy-efficient lighting systems, improving the insulation of ship spaces, and installing efficient management systems to reduce energy consumption (Walker et al. 2019; Tapaninen 2020; Monios 2020; Daniels 2024).

In the shorter term, financial benefits can be achieved through the more economical use of raw materials, which can be realised through the preparation of food that is desired rather than planned but not preferred by the crew. The

implementation of this approach can contribute to a significant reduction in food waste. When the crew receives the food they prefer, the likelihood of the entire portion being consumed is increased, minimising the amount of food wasted. This, in turn, leads to the more efficient use of available resources and reduces the burden on waste management systems.

Also, a better understanding of crew behaviour and preferences allows for the optimisation of raw material planning and procurement. When it is known what products are most desired, deliveries can be more accurately planned, resulting in the more economical use of resources. This would not only help improve efficiency but also create economic benefits for the organisation (Theodorou and Litina 2024; Itani 2024; Beall 2017; Delbeke and Vis 2015), and savings can be used to improve working conditions or reinvested in other projects.

In addition, reducing food waste and optimising the use of raw materials can help to have a positive impact on the environment. Less waste means less strain on natural resources and lower carbon emissions associated with processing and disposal. Investing in environmentally friendly systems can demonstrate the ship owners' or operators' commitment to environmental sustainability to stakeholders and improve reputation. Regulatory requirements and standards for environmental sustainability are constantly evolving towards greater complexity and comprehensiveness. Investing in sustainable environmental practices in procurement will not only contribute to compliance with current and future regulations but can also create a competitive advantage.

- Second aspect: Achieving economies of scale.

In order to achieve economies of scale from the size of the provisioning practice, it is necessary to make changes and optimise the sourcing processes and the accurate determination of the required resources. One way to achieve this is through negotiated discounts for larger volumes of provisions to be sourced regularly from the same supplier over time. The process requires negotiating with suppliers for special pricing when large quantities are purchased, which can help reduce costs. The method should be combined with the use of automated inventory management systems, and the accurate calculation of crew requirements can help avoid unnecessary costs and excess inventories (Dyrhauge and Rayner 2023). Optimised supply and distribution processes can also reduce the time and resources spent on these operations (Goyal and Llop 2024).

Another aspect that can be applied is standardising crew menus and purchasing more common provisions that can be used to prepare different recipes and menus, which can reduce the cost of purchasing a variety of products that have different storage requirements, shelf lives, and commodity compatibility. Optimisation can also be sought with the benefits of simplifying the food preparation process for the crew and reducing the need for specialised ingredients.

Another option can be implemented when the ship is in port; using local resources to supply food, such as fresh produce from local markets or local suppliers for more economical prices, may be more economical than transporting goods from other locations. A less commonly applied method for economies of scale is investing in waste management and material recycling technologies (Kopela 2020).

The purchase of innovative specialised waste collection and treatment systems can reduce environmental impacts and extract additional value from waste by converting it into new products or materials.

- Third aspect: Savings on the size and type of transport used.

The optimisation of transport processes for the delivery of provisions to seagoing ships through the use of more efficient means of transport and technologies can reduce fuel consumption to have lower emissions of carbon dioxide and other pollutants than traditional fuels such as diesel and petrol (Behrens and Egenhofer 2011). In addition, the optimisation of supply routes for provisions can contribute to reducing the environmental impact of transport. By choosing more efficient and shorter routes, provision suppliers can reduce fuel consumption and emissions of harmful substances. Technological developments in the field of precise positioning information systems and satellite navigation provide opportunities for the better planning and monitoring of ship routes, taking into account factors such as traffic, weather conditions, and the optimal use of waterways.

Another aspect that can be considered to achieve savings on the size and type of transport is the use of shared resources for provisioning. Instead of provisions being delivered by multiple means of transport for each ship to individually have its own food delivery system, a system of the common use of means of transport could be developed. In practice, this is not easy to achieve, but it is possible by setting up depots for food provisions in the vicinity of or at a port itself, where the delivery can be larger and made by one vehicle, and from the food depot to different ships, several vehicles can be used but now over shorter distances.

- Fourth aspect: The optimisation of storage space.

In addition to the transport sector, optimising storage space both before and after the delivery of provisions can also have a positive impact on improving environmental sustainability.

One way to achieve this is through the use of dedicated storage and inventory management systems to enable the more efficient use of space and resources. An example of good practice in this area is the implementation of automated warehouse management systems to allow staff to monitor and control stock in a more efficient way. Systems can be programmed to optimise the distribution of goods in the warehouse, taking into account factors such as expiry or minimum shelf life and maintaining sufficient product availability at higher-order frequencies. Another important practice is the development of specialised containers and packaging for provision storage to minimise wastage and energy costs. Containers can be made of materials that provide optimal conditions for food storage while being lightweight and resistant to external influences.

- Fifth aspect: Supplier diversification.

The diversification of food provision suppliers is a process by which the list of suppliers is expanded to reduce the environmental risks associated with food transport and production while also contributing to the conservation of ecosystems

and natural resources. One of the main benefits of supplier diversification (Berle et al. 2011; Branch 1982) is the reduction in environmental stresses that arise from long transport routes and the carriage of goods. By reducing dependence on a limited number of suppliers (Mitroussi 2004), offering products from destinations further afield can also reduce the environmental impacts associated with unnecessary fuel use and carbon dioxide emissions (Goksu and Arslan 2024). New suppliers can provide products that are manufactured closer to local markets, reducing the need for long transport distances and, therefore, carbon emissions (Kivalov 2024). Diversifying suppliers creates greater opportunities to use different methods to produce and supply food products. For example, local producers can be brought into the supply chain by offering less processed fresh and seasonal produce with a lower carbon footprint. Also, different suppliers can provide certified organic or sustainably sourced products that adhere to strict environmental standards.

By expanding the number of suppliers, greater opportunities for competition are created, which may lead to better prices for purchased provisions (Pantazi and Πανταζή 2024). A further positive aspect of the process relates to supporting small and medium-sized enterprises that are local producers by giving them the opportunity to become involved in the supply chain, supporting the local economy and creating jobs in communities.

One of the main strategies for supplier diversification is to actively seek and attract new and different suppliers from existing ones (Sarkis and Talluri 2002). The Selection Process (Χάλαρη and Chalari 2021; L. Kendall 1986; Lau and Yip 2017; Grillias and Γρί$\lambda\lambda\iota\alpha\varsigma$ 2023), as well as exploring new opportunities for established suppliers with whom a firm operates to source locally produced products. Furthermore, establishing long-term, mutually beneficial relationships with different suppliers can contribute to the stability and reliability of the supply chain.

Through the systematic analysis and evaluation of the results of the implementation of plans to improve the environmental sustainability of provisioning supply, the strengths and weaknesses of the relevant measures can be identified, and further improvements and adjustments can be proposed where necessary. This will allow the industry to develop and optimise its practices in line with the principles of sustainable development and environmental protection.

4.4.2. A Consumer Perspective on Environmental Sustainability

- First aspect: Educating and informing consumers.

It has been found that providing information on environmental practices implemented in the supply chain can increase crew members' satisfaction and encourage them to choose more sustainable options. Providing information on the environmental and social implications of provisioning can improve consumers' confidence and encourage them to support more sustainable practices.

- Second aspect: Sourcing sustainable food materials.

Sustainable sources of raw food materials and suppliers can have a positive impact on reducing the environmental footprint of feeding crews in the maritime sector. The process can be managed not only through the choice of products, such

as sustainably produced inputs, but also through transparency in the supply chain or support for initiatives aimed at protecting the environment and improving the sustainability of farming and fishing.

It has been found that the main way to reduce the ecological footprint of food on board ships is to choose sustainable sources of raw food materials that are produced with minimal greenhouse gas emissions, respecting the principles of sustainable farming and fishing. Fish products, which are often the staple food on board, can be sourced from suppliers that are certified by organisations such as the Marine Stewardship Council (MSC) or the Aquaculture Stewardship Council (ASC). Certified raw materials involved in menu formulation can ensure that fishing or aquaculture is carried out with due respect for the environment and resources. The supply of fruit and vegetables to ships can also be sustainable by selecting appropriate varieties that are more resistant to disease and insects and that are harvested using sustainable farming methods such as organic farming. Alongside these practices, sources of meat and dairy products can also be chosen according to sustainable principles. For example, meat products may be chosen from farms that practice sustainable animal husbandry and use methods to reduce greenhouse gas emissions, and dairy products may be preferred from farms that maintain high standards of animal husbandry and waste management.

In order to ensure the sustainability of raw food materials, it is not only sufficient to choose the right products but also to consider criteria related to environmental commitment and sustainability in the supply chain when selecting suppliers.

- Third aspect: Supporting local suppliers and long-term partnerships.

Another good idea is to support local suppliers where practicable and feasible. Local farms and fishing boats usually have a smaller carbon footprint than transporting products, and supporting them can contribute to the economic development of local communities.

In addition, ship operators can enter into long-term contracts with their suppliers, including sustainability commitments. Long-term suppliers may be subject to sustainability certifications or compliance with certain farming or fishing standards. Long-term partnerships create stability and encourage suppliers to invest in sustainable practices.

- Fourth aspect: Leveraging technology and innovation.

In order to ensure supply chain transparency and sustainability, ships can use technology tools such as blockchain. The technology allows each stage of food production and delivery to be tracked and recorded in a non-changeable historical record. The use of blockchain contributes to greater transparency and trust between all actors in the supply chain. Also, ships can benefit from the exchange of best practices and experiences between suppliers and producers of raw food materials. Knowledge sharing can contribute to improved sustainable practices and innovation in food production and supply.

In order to promote sustainability in the maritime sector and support suppliers of sustainable raw food materials, shipping companies can engage with various

initiatives and organisations that support sustainability programmes and support projects that work to protect the environment and improve the sustainability of agriculture and fisheries.

For example, shipping companies can support and finance marine ecosystem restoration projects, such as coral planting or reforestation. Another initiative that can be implemented involves supporting and participating in education programmes and awareness campaigns that raise crew and customer awareness of sustainable food practices. Educational programmes should include information on the environmental benefits of sustainable products and ways to reduce the environmental footprint of dining.

Also, innovations in biotechnology can lead to the more efficient production of raw food materials. For example, research in genetic engineering can lead to plants and animals with higher resistance to disease and stress conditions. Innovation in raw food material production can also include the development of new methods for seafood production. For example, the cultivation of adjacent marine species that are not traditionally cultivated may provide new opportunities for sustainable food supply.

Promoting cooperation between scientific institutions and the maritime industry is also important. This type of partnership can lead to knowledge sharing and research supporting sustainable raw food material sources and production methods. Sustainable sources of food, raw materials and suppliers play an important role in reducing the environmental footprint of feeding crews in the maritime sector. The process involves not only the selection of products, such as sustainably produced inputs, but also transparency in the supply chain and support for initiatives to protect the environment and improve the sustainability of farming and fishing.

The main way to reduce the environmental footprint of food on board ships is to choose sustainable sources of raw food materials- products that are produced with minimal greenhouse gas emissions, respecting the principles of sustainable agriculture and fishing. One of the main foods used on board ships is fish products. In order to reduce the impact on ecosystems and support sustainable fishing, fish products that are certified by organisations such as the Marine Stewardship Council (MSC) or the Aquaculture Stewardship Council (ASC) can be selected. Certified raw materials involved in menu formulation can ensure that fishing or aquaculture is carried out with respect for the environment and resources. In addition to fish products, seafood ingredients include other marine organisms such as seaweed and shellfish. The supply of fruit and vegetables to ships can also be sustainable. Factors such as choosing varieties that are more resistant to disease and using organic farming are important here. Alongside these practices, sources of meat and dairy products can also be chosen according to sustainable principles. For example, meat products can be chosen from farms that practice sustainable animal husbandry and use methods to reduce greenhouse gas emissions, and dairy products can be preferred from farms that maintain high standards of animal husbandry and waste management. In order to ensure the sustainability of raw food materials, it is not enough to choose the right products. It is also important to work with suppliers who share a commitment to environmental protection and sustainability in the supply chain.

4.4.3. Process Perspective on Environmental Sustainability

- First aspect: The optimisation of transport processes.

In the framework of the optimisation of transport processes in maritime supply, the efficient management of food resources is essential. Reducing food consumption can be achieved by strategically reducing the amount of food wasted. Efficiency can be achieved by implementing advanced consumption forecasting and stock optimisation methods that minimise the risk of overstocking and subsequent food waste. In addition, the integration of systems to monitor storage conditions and the shelf life of food products can contribute to the more efficient use of available resources. Such systems allow for the timely identification of products approaching their expiry date, which, in turn, allows for the implementation of appropriate loss prevention measures. This not only results in a reduction in food waste but also contributes to the overall environmental sustainability of the supply processes on board ships.

In the context of environmental sustainability in the supply of marine vessels, toner and ink recycling is an important aspect of process optimisation. The use of recycled toner and ink materials not only reduces waste associated with printing consumables but also reduces the need to produce new ones, resulting in lower energy and resource consumption. In addition, implementing programmes to collect and recycle empty toner and ink cartridges on board ships can significantly reduce the environmental footprint of the maritime industry. These programmes not only ensure proper waste management but also promote a culture of sustainable consumption among crew. In this way, toner and ink recycling become a key component of an overall strategy to minimise the negative environmental impact of marine supply.

As part of efforts to increase energy efficiency and reduce the environmental footprint of supplying marine vessels, switching off computers when not in use is an important practice. Leaving computers and other electronic devices switched on during periods of inactivity results in unnecessary energy consumption that can be avoided by the simple measure of switching them off. Implementing this practice not only helps to reduce energy costs but also extends the life of hardware by reducing the need for frequent equipment replacement. Furthermore, switching off computers and electronic devices during long layovers can play a role in the overall energy efficiency and sustainability strategy of maritime operations, helping reduce ship operations' carbon footprint and improving resource management.

Another opportunity to improve processes could be the introduction of reusable containers and sustainable transport equipment. The use of such containers reduces the need for disposable packaging, resulting in a significant reduction in waste and resources spent on their production and disposal. Reusable transport containers and equipment can contribute to the more sustainable management of logistics processes by reducing the overall environmental footprint of the supply chain. These containers are designed to be more durable and can withstand multiple cycles of use, resulting in less need to produce new materials and reduced waste generation. In addition, implementing such sustainable practices can help improve operational efficiency by reducing packaging material and waste management costs. One option for implementing this strategy is the incorporation of reusable pallets into the logistics

operations of marine vessels. These pallets, made of stronger and more durable materials such as plastic or metal, have a significantly longer service life than traditional wooden pallets. This reduces the need for frequent replacement and, therefore, results in less waste.

Using reusable pallets also reduces the resource consumption associated with producing new pallets and minimises the carbon emissions associated with their transportation and disposal. In addition, these pallets are more resistant to wear and damage, making them more economical and efficient for long-term use. By implementing such sustainable solutions, shipping companies not only reduce their environmental footprint but also demonstrate a commitment to improving their operations and achieving long-term sustainability. This, in turn, can help to create a positive image and increase competitiveness.

Another opportunity to improve processes is to reduce unused space in delivery vehicles. The efficient use of space for transporting supplies and equipment to ports can significantly reduce the number of shipments required. In addition, the use of standardised containers and modules can facilitate the more efficient stacking and securing of cargo, which also contributes to maximising the use of available space. These approaches not only reduce the need for additional runs but also increase transport safety by reducing the risk of uneven loading and damage during transport. In the long term, the more efficient use of cargo space is an important step towards reducing the environmental footprint of logistics operations in the maritime industry.

Optimising the use of vertical space in trucks is part of efficient logistics operation management. Utilising all available space, including height, allows more freight to be transported in one journey, reducing the need for extra journeys and resulting in lower fuel costs and lower carbon emissions. This optimisation can be achieved by using racking and modular load stacking systems that allow for the better organisation and stable attachment of different load units at height. It is also important to ensure even weight distribution to avoid risks of tipping or damage during transport. The use of appropriately designed containers and pallets that can be stacked stably on top of each other also contributes to the efficient use of vertical space. In addition, the implementation of automated stacking technologies can facilitate and speed up the process, minimising errors and increasing space utilisation. The measures presented can not only increase the efficiency of freight transportation but also support efforts to reduce the environmental footprint of transportation operations by allowing more freight to be transported with fewer resources and fewer trips.

- Second aspect: The optimisation of procurement processes.

One effective way to optimise procurement processes can be to reduce paper consumption in the paperwork associated with provisioning. This can be achieved through digitisation and the introduction of electronic systems for managing stock, orders, and logistics operations. The use of electronic documents and electronic signature systems can not only reduce the need for physical documents but also speed up handling processes, increase transparency, and reduce the risk of errors associated with manual data entry. In addition, digitisation allows for easier real-time tracking and analysis of data, improving decision-making and facilitating supply

chain optimisation. Light sensors can be used inside an aisle to turn on the light only where there is someone.

The optimisation of food provisioning processes can be significantly improved by the use of advanced systems to maintain the optimal storage temperature of provisions. These systems are designed to ensure that food supplies are stored at the exact temperature required to maintain their freshness and quality throughout voyages. Incorporating intelligent temperature control systems and automated refrigeration technologies reduces the risk of food spoilage while optimising energy consumption on board. In addition, these advanced systems can also integrate real-time monitoring sensors to alert the crew to deviations from optimal conditions, enabling rapid corrective action and minimising wastage. These technological improvements not only increase the efficiency of food storage but also contribute to sustainable resource management by reducing costs and minimising waste.

- Third aspect: Optimising transport flows and logistics.

Optimising transport flows at the time of delivery and in the warehouse can significantly improve the efficiency and sustainability of a ship's provisioning processes. When transport flows are optimised, the handling time of goods from the time of delivery to the warehouse and from the warehouse to the points of consumption on board is reduced, which shortens the period during which food products may be exposed to adverse conditions. This helps to preserve the quality of food provisions.

In addition, better inventory management is possible when transport flows are predictable and transparent, facilitating the planning and coordination of deliveries. This prevents problems such as overstocking or food shortages. At the same time, optimisation leads to reduced logistics and warehouse management costs through more efficient use of vehicles and warehouse space, resulting in lower fuel, labour, and warehouse service costs.

Optimisation also minimises the loss of food provisions and reduces the risk of damage during transport and excessive downtime in the warehouse, which contributes to more sustainable resource management and less waste. Operational efficiency is also increased, as improved coordination between the different links in the supply process creates a smoother supply chain that is able to respond more quickly to changes in needs or conditions. Thus, food products spend less time outside optimal storage conditions, extending their shelf life and ensuring that the crew will have high-quality and safe food.

Thus, optimising transport flows not only improves supply chain efficiency but also results in lower costs, less waste, and better quality and freshness in food provisions on board.

The use of doors with auto-closing sensors can significantly improve the efficiency and management of shipboard food provision stores. Such doors ensure that storage doors remain closed when not in use, thus minimising energy waste and maintaining a stable storage temperature. This is particularly important for maintaining the freshness and quality of food products, as a consistent temperature is key to preventing spoilage.

Automatic door closing also reduces the risk of accidentally leaving doors open, which can lead to the disruption of optimal storage conditions. This contributes to better efficiency in cooling systems, which are not further stressed, and to reduced energy costs. In addition, such technology makes the crew's job easier as the automatic system eliminates the need to manually close the doors, which can be forgotten in a dynamic work environment. The use of doors with auto-close sensors not only ensures the better storage of food provisions but also results in energy savings and better operational efficiency and contributes to maintaining high quality and safety standards on board.

- Fourth aspect: Packaging process optimisation.

For ships' stores for food, provisions can significantly improve sustainable resource management and the overall efficiency of operations. When warehouses are energy-efficient, they use less energy to maintain optimal storage conditions while ensuring that the quality and freshness of food products are maintained. Improvements in energy efficiency can include the use of advanced insulation materials, energy-efficient cooling systems, and smart temperature and humidity control technologies. These measures not only reduce energy costs but also reduce the carbon footprint of ships, which is an important aspect of environmental sustainability.

In addition, energy-efficient warehouses can provide more stable storage conditions, which minimises the risk of food stock spoilage and reduces the need for additional supplies. This, in turn, leads to better operational efficiency and reduced wastage, which benefits both the crew and the environment.

The use of materials with better insulation properties for ship stores of food provisions can significantly improve energy efficiency and provide better storage conditions. Better insulation helps to maintain the desired temperature in the stores, minimising heat loss and reducing the need for additional cooling or heating. This results in lower energy consumption and reduces the costs associated with maintaining optimum food storage conditions.

More effective insulation also reduces the risk of temperature fluctuations that can adversely affect the quality and freshness of food stocks. This is particularly important in preventing spoilage and wastage, which contributes to the sustainable management of the resources on board. In addition, using advanced insulation materials can reduce the potential for condensation and moisture build-up, providing additional protection for stored products and reducing the risk of damage. Investing in high-quality insulation leads to long-term benefits such as lower operating costs, extended shelf life in food products, and increased sustainability in supply operations. This makes insulation a key element for warehouse optimisation and shipboard food provisioning management.

Introducing new technologies for storing food provisions for merchant ship crews can lead to significant improvements in the efficiency and quality of stock management. Advanced storage technologies, such as intelligent temperature control systems, automated inventory management solutions, and innovative packaging methods, can provide better storage conditions and longer product shelf life.

Intelligent temperature control systems allow the constant monitoring and automatic adjustment of storage conditions, ensuring optimum temperature and humidity for all types of food products. This not only protects food from spoilage but also reduces energy costs by optimising the performance of cooling systems. Automated inventory management solutions, such as real-time inventory tracking systems and consumption forecasting programmes, can improve supply planning and coordination. This leads to the more efficient use of resources, reduced wastage, and better readiness to respond to crew needs.

Innovative packaging methods that extend shelf life and preserve product freshness also play a key role in improving storage. These technologies not only protect products from external factors but also facilitate logistics and warehouse management on board.

The introduction of these new technologies for storing food provisions contributes to greater efficiency, reduced costs, and the provision of higher-quality and safer food products for merchant ship crews. This makes the management of provisions more reliable and sustainable, which is essential for long-term maritime operations.

The use of automated transport systems in the delivery and consumption of food provisions for merchant ship crews can significantly improve the efficiency and accuracy of the supply process. Automated systems enable the fast and accurate transportation of food products from warehouses to onboard consumption points while reducing the risk of human error and product damage during movement. The systems can provide the better organisation of the delivery process by automatically optimising the route and timing of transportation, resulting in the more efficient use of resources and reduced operating costs. Greater safety is also achieved with automated transport solutions, as they reduce the need to manually carry heavy loads and thus minimise the risk of crew injury.

In addition, automated systems can be integrated with other inventory management and quality control technologies, allowing for the better real-time monitoring and management of food provisions. This ensures constant access to the necessary supplies, minimising wastage and ensuring that the crew has fresh, high-quality products.

The implementation of automated transport systems in the delivery and consumption processes of food provisions on merchant ships leads to higher operational efficiency, reduced costs, and improved crew service quality. These systems play a key role in modern provisioning management, ensuring the reliability and sustainability of the onboard supply chain.

- Fifth aspect: Sustainable packaging practices.

One option is to require the supplier to take back the packaging in which it delivers the goods, which can significantly reduce waste on board merchant ships. This not only shifts responsibility for packaging to the supplier but also encourages the use of more durable and sustainable materials that can be reused. In addition, this practice reduces the need to store and manage waste on the ship while promoting a circular economy and reducing the environmental footprint.

Establishing and maintaining a wrap and pallet management and return system ensures the efficient use of resources and reduces costs associated with the purchase of new pallets. Such a system allows the reuse of pallets while facilitating the ship's logistics operations. By optimising pallet turnover, shipping companies can reduce waste and improve supply chain efficiency.

Alternatively, the use of lighter packaging materials contributes to a reduction in the overall weight of the cargo on board, which, in turn, results in lower fuel consumption and fewer greenhouse gas emissions. Lightweight packaging also facilitates the handling and transportation of goods, reducing the workload of the crew and increasing the efficiency of loading and unloading operations.

It is good practice for packaging to be made of biodegradable materials to reduce the environmental impact of shipping operations. Materials degrade naturally in the environment, reducing the amount of plastic waste and ocean pollution. The use of biodegradable packaging is part of a broader strategy for sustainable resource management and the protection of the marine environment.

Using recycled materials for packaging is an effective way to reduce the need for new raw materials and to protect the environment. Recycled packaging also reduces waste and the carbon footprint of shipping operations. The introduction of such materials is a key step towards achieving more sustainable and environmentally responsible practices in shipping. The use of recyclable packaging materials allows for easier waste management on board, as packaging can be collected and recycled after use. This reduces the amount of waste that has to be disposed of and supports environmental protection efforts. Recyclable packaging is an important part of the strategy to minimise the environmental footprint of shipping operations.

Where practicable, the design of packaging may be modified to facilitate the separation and sorting of different types of materials, contributing to more efficient recycling and waste management. Packaging that is easy to disassemble and sort allows the crew to quickly and efficiently separate different materials for recycling. This reduces the time and effort required to process waste and increases the percentage of materials successfully recycled.

The optimisation of secondary and tertiary packaging reduces unnecessary material usage and facilitates the transportation and storage of food provisions on board. This involves using a minimum amount of packaging material that still provides the necessary protection for the products. Less packaging means less waste and lower packaging material management costs, which contributes to more efficient and sustainable operations.

4.4.4. Learning and Development Perspective

- First aspect: Training for effective environmental sustainability management.

Implementing sustainable practices in the provisioning of seagoing vessels requires targeted training programmes to address the specific needs and challenges of this sector. Crew and management training on board is essential to achieve long-term environmental sustainability, with an emphasis on practical skills, awareness, and knowledge of sustainable resource management. Programmes should focus on operational training that aims to prepare the crew for the effective

and environmentally sound management of the ship's food stocks. This includes training on the proper storage of provisions, optimal use of energy resources, and minimisation of food waste. Programmes should also cover the implementation of new monitoring and control technologies that allow the crew to monitor the status of stocks in real time and take timely action to prevent losses.

Another important component of the training is raising awareness of the environmental implications of different aspects of provisioning. Training programmes should include modules that address topics such as the carbon footprint of food products, opportunities to reduce energy costs, and the importance of sustainable food sources. This knowledge is necessary to build an environmental culture on board and encourage the adoption of practices that contribute to sustainable development.

There is also a need to develop management skills to enable masters and other ship managers to integrate sustainable practices into day-to-day operations. Training programmes in this regard should provide strategic planning and decision-making tools that reflect a commitment to environmental sustainability. In this regard, it is important to provide training on supply chain management, including selecting suppliers that comply with environmental standards and implementing sustainable transportation and storage methods.

In the context of the continuous evolution of maritime transport, training programmes need to be dynamic and adaptable, being updated in line with new technological developments and regulatory requirements. This requires the establishment of continuing training structures to provide crew and management with the opportunity to update their knowledge and skills. Online platforms and simulation technologies can play an important role in this process by offering flexible and interactive training methods.

Effective training to implement sustainable practices should be accomplished by developing and implementing comprehensive and adaptive training programmes to address the challenges of sustainable resource management while contributing to environmental protection.

- Second aspect: The development of an environmental culture on board.

Developing an environmental culture on board seagoing ships is an essential step towards sustainable resource management and reducing the environmental footprint of maritime transport. In order to be effective, this effort must be directed at creating a deep environmental awareness among crews that motivates them to implement and comply with sustainable practices in every part of their work.

The first step in creating an environmental culture on board is building awareness of the importance and consequences of environmental behaviour. This can be achieved through regular training sessions that address topics such as climate change, ocean pollution, and the role of shipping in global environmental challenges. Training should include concrete examples and case studies that illustrate how crew actions can significantly impact the environment. In this way, the crew will understand that their every choice—from waste management to energy resource use—contributes to the bigger picture of environmental sustainability. Promoting environmental awareness also requires incorporating sustainable practices into a

ship's daily operations. This can be achieved by putting in place clear policies and procedures that encourage environmentally responsible behaviour. For example, setting up a system for the separate collection and recycling of waste on board, the use of energy-efficient appliances and technology, and encouraging the minimal use of plastic and other non-environmentally friendly materials are all important steps towards sustainable management. These policies should be clearly communicated to the crew and their compliance should be monitored.

In addition to formal training programmes and policies, it is important to create an environment where environmental behaviour is encouraged and valued. This can include creating recognition and reward systems for crews that demonstrate outstanding commitment to sustainable practices. For example, rewarding crews or individual crew members for reducing energy consumption or successfully implementing innovations to reduce waste can encourage others to follow suit. Integrating an environmental culture into the day-to-day operations of a ship also requires the support of management. Masters and senior officers should serve as an example to other crew members, demonstrating a commitment to sustainable resource management and encouraging responsible behaviour. Leadership plays a key role in establishing standards of behaviour and creating a culture that prioritises environmental protection.

In conclusion, creating and fostering environmental awareness among marine ship crews requires a combination of education, the implementation of sustainable practices, the encouragement of environmentally responsible behaviour, and leadership that serves as an example. Through these efforts, a lasting environmental culture can be created on board that contributes to sustainable resource management and environmental protection in maritime transport.

- Third aspect: Ways to motivate and involve crew in sustainable sourcing processes.

Motivating and engaging crew in sustainable sourcing processes on marine vessels is key to successfully implementing environmentally friendly practices and achieving sustainability in maritime transport. In order to be effective, this process needs to include a variety of approaches that engage the crew and encourage their active participation in sustainable resource management.

One of the main ways to motivate crew is through training and awareness. When crew members understand the importance of sustainable sourcing and their actions' impact on the environment, they are more likely to become actively involved in these processes. Training programmes addressing waste reduction, optimal resource use, and energy efficiency can raise awareness and build environmental consciousness. These programmes should be practically oriented and provide the crew with concrete skills and knowledge that they can apply in their daily work.

Another important means of motivation is to create a system of recognition and rewards. Crews actively participating in sustainable practices or offering innovative solutions to improve sourcing can be rewarded or incentivised. This can include both material rewards and symbolic recognition such as certificates or public celebration of their contribution. Such a system creates competition and encourages crew to contribute to sustainable resource management.

Involving the crew in the decision-making process is another effective way to encourage their participation in sustainable sourcing. When crew members have the opportunity to express their ideas and opinions on the management of provisions and other resources, they feel more engaged and motivated to implement sustainable practices. Regular meetings and discussions on sustainability issues can provide a platform for sharing experiences and suggestions for improvements.

It is also important to create a work environment where sustainable behaviour is the norm. Shipboard leaders should set an example and encourage crew to comply with environmental standards and practices. When sustainability is integrated into the corporate culture and daily operations, the crew will be more inclined to adopt it as a core principle of their work.

Technology can also play a role in crew motivation and participation. Interactive platforms, mobile apps, and online monitoring systems can provide crew members with easy access to information and tools to help them monitor and manage their activities in line with sustainable practices. This not only makes processes easier but also increases awareness and engagement.

Last but not least, it is important to create a sense of common purpose and cooperation among the crew. When crew members are aware that their efforts are part of a larger environmental and sustainability effort, they are more likely to engage actively. Events, campaigns, and projects that highlight the importance of collective efforts can strengthen this sense of community and stimulate greater engagement.

In conclusion, motivating and engaging crew in sustainable sourcing processes requires a combination of education, recognition, involvement in decision-making processes, leadership, technology, and creating a sense of common purpose. By implementing these approaches, maritime companies can ensure active and sustainable crew participation in resource management, which is essential for the long-term sustainability of maritime transportation.

- Fourth aspect: The role of management in promoting environmental sustainability in shipping provisions.

The role of management in staff training and development is key to achieving sustainability and efficiency in maritime transport. Ship and company management plays a central role in fostering a culture of learning and continuous professional development that is essential to adapting to new demands and challenges related to sustainable sourcing and environmental protection.

First and foremost, management must create and maintain an appropriate training infrastructure that provides staff with the resources and development opportunities they need. This includes investing in training programmes, modern training technologies and tools, and developing up-to-date and relevant courses for modern maritime transport. Providing access to online platforms, interactive simulations, and other digital resources can also facilitate the learning process and make training more flexible and accessible.

Second, company and ship management must be actively involved in the process of identifying training needs. This can be achieved through regular assessments of crew skills and competencies as well as feedback from employees on their needs and

challenges. Management can use these data to tailor training programmes to meet specific staff requirements and address any knowledge or skill gaps.

In addition, management should encourage and support staff participation in learning initiatives by creating a stimulating learning environment. This may include offering financial incentives, such as bonuses or covering the cost of training, as well as non-financial incentives, such as recognition and career opportunities for those who actively participate in training and show progress. Including training as part of the performance appraisal process can also encourage staff to engage in continuous professional development.

Management also plays an important role in creating a learning culture on board ships. Ship and company leaders must lead by example, demonstrating a personal commitment to learning and development. They should encourage open communication and knowledge sharing among the crew, creating an atmosphere where learning is part of daily work. This can be achieved through regular discussions of new ideas, techniques, and technologies, as well as by providing time and space for onboard learning.

Finally, management must ensure the integration of training programmes with the long-term strategic goals of the company. Training should not be seen as an isolated process but as an integral part of the organisation's overall development strategy. This means that training initiatives must be planned and executed in a way that supports sustainable development, board safety, and company competitiveness.

The role of management in staff training and development is critical to the success of any maritime company. Through active support, strategic planning, and the creation of a stimulating environment, management can encourage the continuous professional development of crew, thereby contributing to the achievement of sustainable and efficient maritime operations.

- Fifth aspect: Innovation in and research on environmental sustainability.

Innovation and research play a key role in developing more sustainable methods of food production, transport, and storage, which are essential to finding solutions that reduce the environmental burden on the shipping supply chain. These efforts are particularly important in the context of maritime transport, where efficient resource management and waste reduction can have a significant positive effect on the environment.

Developing sustainable food production methods starts with adopting farming practices that minimise the use of chemicals and pesticides, conserve water resources, and improve soil fertility. In this context, research on sustainable agriculture and biotechnology can offer new solutions that increase productivity while reducing harmful environmental impacts. Integrating such methods into the supply chain of ships can lead to healthier and more sustainable food sources for crews.

In food transportation, innovation plays an important role in reducing greenhouse gas emissions and optimising energy efficiency. The development of new fuels, such as biofuels or zero-emission fuels, as well as the introduction of energy-efficient engines and onboard energy management systems, can significantly reduce the carbon footprint of maritime transport. In addition, research on logistics

and transport routes can offer more optimal solutions that minimise transport time and reduce energy consumption.

Onboard food storage is also an area where innovation can lead to significant improvements in sustainability. Developing new packaging technologies that use recyclable or biodegradable materials can reduce waste and preserve food quality for longer. The implementation of intelligent temperature and humidity management systems in storage facilities can also help reduce energy consumption and prevent food loss due to spoilage.

Support for research and innovation projects is critical to achieving these goals. By funding and promoting research into sustainable agriculture, new transport and storage technologies, and the development of new materials, maritime companies can find innovative solutions to make their operations more environmentally friendly. This support can take the form of both direct funding for scientific projects and partnerships with universities and research institutes to work on specific challenges related to maritime transport.

Putting the results of research and innovation projects into practice also requires the active involvement of ships' management and crew. For these new methods and technologies to be successfully integrated, training and the adaptation of operational processes are required, as well as the establishment of clear standards and procedures to guide the implementation of sustainable practices.

Implementing sustainable practices in maritime transport is a major challenge for companies in this sector. These difficulties stem from both the nature of the industry itself and the specific requirements and constraints associated with maritime operations. A review of the main obstacles maritime companies face can shed light on the key aspects that need to be addressed to achieve efficient and sustainable resource management.

The first and perhaps most significant difficulty relates to the high upfront costs of implementing sustainable technologies and practices. Investments in new energy-efficient engines, waste management systems, and advanced food storage and transport technologies often require significant financial resources. Many maritime companies, especially smaller and medium-sized enterprises, lack the capital needed to finance these improvements, slowing the transition to sustainable operations. In addition, the regulatory framework related to sustainability is complex and varies considerably across jurisdictions. Maritime companies often have to comply with a multitude of national and international regulations, which can be not only stringent but also contradictory. This requires additional resources to understand and comply with legislation and to adapt operations to meet the different requirements. Companies are challenged to implement sustainable practices that not only meet existing standards but also anticipate future regulatory changes.

Lack of access to new technologies and innovation is also a significant barrier. While there is growing interest in sustainable solutions, not all companies have access to the latest technologies or the expertise to help them implement them effectively. This can lead to an uneven playing field between different players in the industry, with larger companies with more resources able to take advantage of new technologies more quickly and effectively while smaller companies are left behind.

In addition, cultural and organisational barriers often hinder the implementation of sustainable practices. In many cases, sustainable initiatives require a change in the mindset and actions of employees and management. Resistance to change, a lack of sufficient awareness and knowledge about the benefits of sustainability, and a lack of commitment from leaders can hinder the effective implementation of sustainable practices.

Another significant challenge relates to supply chain management. Sustainable supply management requires close cooperation with suppliers who also have to comply with environmental standards. This is often difficult to achieve as not all suppliers can or are willing to adopt sustainable practices. This lack of consistency in the supply chain can hamper shipping companies' efforts to reduce their environmental footprint.

Finally, uncertainty about the long-term benefits and returns of investing in sustainable practices can also be a barrier. Although sustainable practices can lead to significant savings and reputational improvements in the long term, many maritime companies are hesitant to take the risk of significant upfront investments without a clear guarantee of their return.

In conclusion, maritime companies face a number of challenges in implementing sustainable practices, including high costs, complex regulations, limited access to technology, cultural barriers, and supply chain management. Despite these difficulties, sustainability remains a key goal for the industry, and successfully overcoming these obstacles will require coordinated effort, innovation, and strong leadership.

Although progress has been made in the area of the environmental sustainability of ship provisioning, much room remains for opportunities for further research and improvement. One key area is the development of new sustainable materials for the packaging and storage of food products on board ships. Although biodegradable and recyclable options are already being incorporated, current materials still need improvement in their durability and functionality. Research in this area can focus on creating packaging that not only reduces the environmental footprint but also preserves product quality and freshness for longer.

The optimisation of the storage and transport of food products is also an important aspect that requires further attention. The development of intelligent temperature and humidity control systems can lead to the more efficient management of the storage conditions for provisions while reducing ships' energy consumption. This, combined with innovation in transport systems, has the potential to reduce carbon emissions and make supply more sustainable.

Waste management is another critical area where further research is needed. The integration of a circular economy into the supply chain of ships can offer new solutions for recycling and reusing materials. Research into methods to reduce food waste, as well as the creation of sustainable supply chains, can significantly improve the environmental profile of maritime transport.

Digitalisation and the deployment of new technologies such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain also represent promising areas for research. These technologies can provide better resource management, supply chain optimisation, and greater transparency in processes, which, in turn,

will contribute to greater sustainability. Further research could also focus on the social and economic aspects of sustainability, including studying the impact of sustainable practices on the working environment and economic efficiency of maritime companies.

In summary, despite the successes achieved, the environmental sustainability of shipping provisions still requires significant research and innovation efforts. With a focus on the development of new materials, storage, and transport optimisation, waste management, and the integration of new technologies, the industry can take significant steps towards a more sustainable future.

4.5. Conclusion of Chapter Four

Chapter Four presents an in-depth analysis of environmental sustainability in the context of food provisioning for marine crews, focusing on a variety of aspects related to process optimisation, financial efficiency, and the development of environmental awareness among crew. The main findings from the topics covered highlight the importance of an integrated approach that covers all stages of the supply chain, from the production and packaging of food products to their storage and transport.

The survey presented at the beginning of this chapter shows considerable variation in the extent of the implementation of sustainable practices among maritime companies. Despite the awareness of the importance of environmental sustainability, the results show that there is a lack of standardised approaches and sufficient innovation in the area of provision packaging and transport. This highlights the need for better coordination and the development of common standards to facilitate the implementation of sustainable practices.

The financial perspective analysis in this chapter reveals that investments in sustainable technologies and practices can not only reduce the environmental footprint of maritime transport but also lead to significant economic benefits in the long term. Achieving economies of scale, storage optimisation, and supplier diversification are key factors that can improve companies' financial efficiency and competitiveness while promoting sustainability.

While optimising transport and procurement processes is at the heart of environmental sustainability, it is also important to address the development of an environmental culture among crew. This chapter focuses on the need for continuous training and development to foster environmental awareness and actively engage crew in implementing sustainable practices. In this context, the role of management is critical, as leaders must encourage and support sustainable resource management efforts.

The analysis presented in Chapter Four shows that environmental sustainability in the provisioning of marine vessels is a complex process that requires a multifaceted approach and coordinated efforts. Implementing sustainable practices not only contributes to environmental protection but also to improving the efficiency and profitability of maritime operations. This chapter's key findings highlight the need for investment in innovation, human resource development, and the establishment of standardised environmental practices to ensure maritime transport's long-term sustainability and success.

5. Conclusions

This monograph presents a comprehensive analysis of sustainable logistics services in the provision of food for merchant ships, focusing on three main aspects: economic, social, and environmental sustainability. The research conducted offers valuable insights into the challenges the maritime industry faces in ensuring efficient and sustainable provisioning practices while addressing the broader goals of the United Nations Sustainable Development Agenda.

Chapter One examines the current state and challenges associated with supplying ships with food products, outlining key requirements and highlighting the importance of sustainability in the context of food logistics. By introducing methods to measure sustainability and ecological footprint, a solid foundation for understanding the critical dimensions of sustainable onboard food sourcing is established.

Chapter Two focuses on the economic aspect of sustainability, using proven methodologies for data collection and analysis to assess the financial sustainability of sourcing practices. Through statistical models and the application of the SBSC strategic framework, key strategies are identified to improve financial performance, enhance customer satisfaction, optimise processes, and promote organisational learning.

In Chapter Three, this monograph focuses on the social aspect of sustainability. Current sourcing practices are assessed through a focused survey that measures social sustainability and identifies areas for improvement. The results show that integrating social aspects into sourcing logistics not only has the potential to improve crew well-being but also strengthens the sustainability of the entire supply chain.

Chapter Four examines the environmental aspect of sustainability, offering an in-depth analysis of ecological practices in the maritime industry. This study highlights the importance of reducing the environmental footprint of sourcing processes, supported by detailed survey results and applied statistical analyses. Through the application of the SBSC framework, strategies are proposed to balance financial goals with environmental protection, customer expectations, and the continuous improvement of environmental practices.

This monograph is both a theoretical contribution to research and a practical guide for stakeholders in the maritime industry, offering clear pathways for sustainable development in logistics services for food supply. Integrating sustainability principles into sourcing processes is not just an option but a necessity for the long-term success of maritime operations. Future research can build on this work by exploring emerging technologies and innovative solutions that further support sustainable sourcing.

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