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Smart and Green Ports

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Abstract: The rapid growth of world trade and the progress of digitization have led to the need for more complex infrastructures to support the increased amount of cargo and the adaptation of logistical support to the new data. At the same time, tackling climate change is one of the most important challenges the global community is facing today, and ports, which are major sources of pollution, must contribute to the protection of the environment. In this regard, smart ports, through the use of technological innovations in order to enhance port activities and services, aim to increase the competitiveness and economic viability of an area, while, at the same time, contribute to the reduction of greenhouse gas emissions and energy consumption. The purpose of the present paper is to present the principles on which the construction and operation of a smart and green port should be based, as well as ways to make the port industry more environmentally friendly.

Key words: ports, smart ports, green ports, environment

1. Introduction

According to a widespread definition, a port is considered as "a gateway through which goods and passengers are transported by ships to and from the land" [1]. Ports are pillars of the economic and social development of regions and countries worldwide. They are the key points of transition from one mode of transport to another and are of vital importance to the flow of international trade. In today's globalized environment, the port industry faces constant challenges, arising from social, economic and technological developments, in order to ensure the possibility of maintaining a competitive advantage in the market. Structural changes in trade patterns, natural disasters and terrorist attacks combined with the pursuit of environmental protection and sustainable development, as well as the rapid development of information and communication technology have led to the need to modernize port infrastructure and operations.

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In this context, emerged the concept of smart and green ports. Smart ports depend on the use of new technologies to improve the overall efficiency and competitiveness of their operations, while green ports have low energy consumption and pollution reduction as their main objective. Green development, flexibility, personalization, collaboration, intelligence and liberalization are the key aspects of the development of a smart and green port.

In general, the two concepts are complementary, since on the one hand green development is an important aspect of a smart port and on the other hand the application of technological innovations of a smart port is the key means to achieve the goal of a green port. The mutual development of the two concepts contributes to the enhancement of the competitiveness between ports and the achievement of sustainable development.

1.1 Importance of a Port

The easy access offered by the seas and oceans combined with the economic and energy efficiency of shipping have made ports a hub for trade [2], while at the same time they are vital points to the connection

between sea and land transport [3]. According to the European Commission, 80% of the world trade is carried out by sea [4].

In addition, port activities contribute directly to the increase in employment, the attraction of new investments and the increase in GDP. At the same time, ports and port facilities form the basis for multiple economic activities (maintenance and exploitation of marine infrastructure, exploitation of ships and their services, land transport, logistics services, cargo services, etc.), contributing even more to the economic development and social welfare at local and supra-local level.

2. Evolution of Ports: Port Generations

Several attempts have been made in the literature to classify ports into typologies and analyze their role and functions, without however a commonly accepted framework, due to the complexity and heterogeneity of ports. In 1992, the first systematic attempt to categorize ports is made at the United Nations Conference on Trade and Development (UNCTAD) in Genoa. It is a comprehensive approach to the characteristics and evolution of the port industry that led to the classification of different types of ports into categories called "Port Generations".

The UNCTAD approach was based on the fact that certain dominant characteristics of ports could be associated with distinct time periods, resulting in the distinction of ports into three port generations. Over the years, globalization and continuous changes at social, economic and political level created a high competitive environment, characterized by high levels of uncertainty. The need to adapt to this new environment led port authorities and administrations to adopt a new logistics approach based on agility. At the same time, the formation of port networks allowed ports to improve their competitive advantage in the global economic market. Thus, in 1999, UNCTAD proposed the arrival of the fourth generation port [5].

In the modern environment, where the port industry sector faces continuous challenges, such as structural changes in the trade pattern, natural disasters, terrorist attacks etc., while at the same time the pursuit of environmental protection and sustainable development and the rapid development of information technology dominate [6], the framework of the four port generations is not sufficient to reflect the functions of ports required by the needs of their users and the community [7]. The fifth generation ports integrate the service functions of the ports of the previous four generations, while, at the same time, adapting to the innovative trend of smart and green technology, emphasizing in the integration of advanced IT and telecommunication technology systems and environmental protection [8].

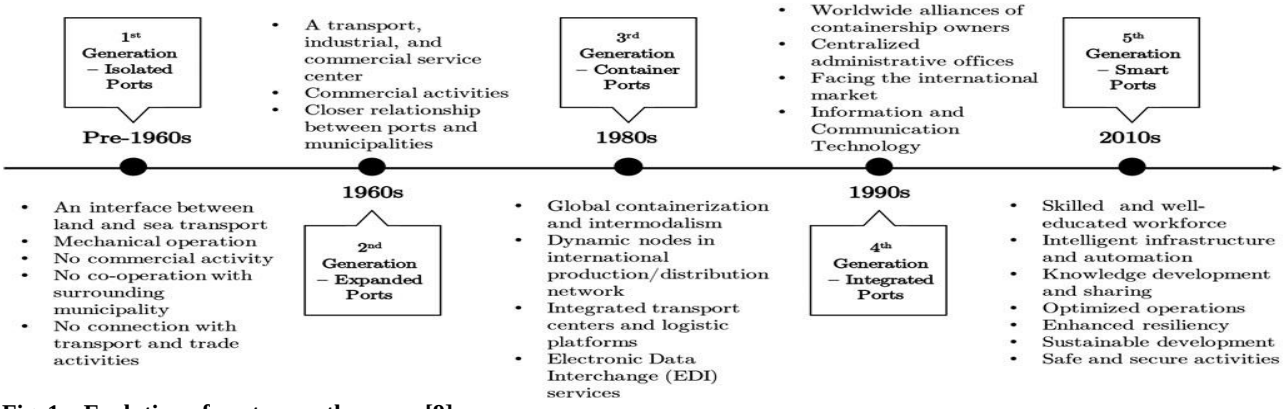

Fig. 1 Evolution of ports over the years [9].

3. Smart Ports

A smart port, as part of a smart city, aims to use technological innovations to enhance port activities and services and provide a socio-economic boost to cities and regions with improved international trade competitiveness, while minimizing energy consumption and traffic. Moreover, a smart port brings together specialized and highly trained personnel, smart infrastructure and automation, aiming to facilitate the development and exchange of knowledge, optimize port operations, strengthen its resilience, achieve sustainable development and ensure safe operations [9].

In other words, a smart port achieves results without creating new challenges internally or elsewhere in the supply chain ecosystem, minimizes the negative impact of its activities on the natural environment and strengthens surrounding communities economically and socially. The benefits of the new technologies allow a smart port to:

- improve its efficiency in order to gain a competitive advantage,
- increase its resilience to economic shocks or disruptive forces,
- achieve maximum value extraction from physical assets,
- develop new revenue streams based on digital value propositions,
- increase employee engagement and well-being,
- achieve its environmental commitments.

3.1 Digital Technologies

The rapid development of technology has significantly contributed to the formation of the modern environment. The development of advanced information and communication technologies and automated systems provides significant advantages in all stages of the production and trading of goods, as well as an important tool for managing issues related to environmental protection, energy management and safety of ships, workers and all stakeholders in a modern port.

Smart ports are designed to operate with full use of smart technologies and automations. Big Data and Blockchain technologies, Artificial Intelligence, the Internet of Things and 5G networks are main pillars for the development and operation of a smart port.

4. Green Ports

A green port is a port of sustainable development, which not only meets environmental requirements, but also brings significant economic benefits. The economic and social development of ports should not exceed the carrying capacity of the corresponding natural system. Therefore, the essence of creating a green port consists in the existence of balance between the environmental and economic effects resulting from its operation [10]. The main objective of a green port is to achieve economic efficiency and environmental protection in the port complex and to ensure the leading position of the port in the modern market environment [11].

The concept of a green port essentially consists of the integration of environmentally friendly activities, operations and management, aiming at the efficient use of resources to reduce negative impacts, raise the level of management and improve the quality of the natural environment of the port area. The adoption of environmental legislation and policies that promote environmental protection, especially in the port and marine areas that are more exposed to pollution risks from shipping and navigation, the enforcement of policies to reduce gas emissions, the appropriate design of the port landscape to include trees that contribute to the absorption of noise and the reduction of pollution, the use of renewable energy sources and the enforcement of sustainable practices (e.g., recycle and reuse of materials) are essential measures that should be taken in order to create a green port.

4.1 Energy Management

In recent years, energy consumption has been one of the main issues that preoccupy port administrations. By taking actions to improve energy efficiency, minimize energy consumption and save resources, significant financial benefits can be obtained and, at the same time, the environmental footprint of ports can be reduced. In this direction, a wide range of technological solutions and operational measures addressing different processes have been implemented to further improve the current energy efficiency of ports.

On the one hand, the use of different forms of energy, such as renewable energy sources (wind energy, solar energy and different forms of energy of the oceans, e.g., wave and tidal energy), Cold ironing systems and alternative fuels (LNG, biofuels, methanol, hydrogen and low-sulphur fuels), should be considered so as to reduce the environmental burden caused from the power and fuel currently used in ports [12]. On the other hand, in terms of maritime activities, reducing the speed of ships during their approach and minimizing the waiting time in the port can contribute to the improvement of the port's energy efficiency.

At international level, a number of measures have been established by the IMO to limit SOx and NOx emissions from ships, such as:

- Drafting of regulations, for example the MARPOL 73/78 Convention.
- Designation of Emission Control Areas (ECAs) in cooperation with national governments, mainly in the Baltic and North Seas, as well as around the Atlantic and Pacific coasts.
- Establishment in 2013 of the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) for CO_2 emissions for ships over 400 tons.

In conclusion, the promotion of technologies and environmental practices contributes to the increase of the competitiveness of the port, while, at the same time, has a positive impact on the local and regional community.

5. Suggestions

In the coming years, seaports will have to be able to face several challenges in order to remain competitive. Globalization, the increasing demand for goods, the ever-increasing volume of ships and goods and the proper use of energy resources are some of the issues that port authorities should be able to deal with. The transition to a "smart and green port" model, with the application of digital technologies and green policies in all infrastructure and operations within the port, is now necessary for all ports worldwide.

Greece, a country that has several ports of various sizes, should not be an exception. Despite the fact that is the main gateway for people and goods to south-eastern Europe and the eastern Mediterranean, the Greek ports are quite behind in smart systems and green development practices. In this regard, the following interventions could be applied in the Greek ports, in order to become competitive in the European and the global shipping industry.

- Elaboration of studies an full costing for the installation of the necessary smart systems in all Greek ports, for the better planning of the central government in finding financial resources and tools.
- Immediate installation of an early warning system for extreme weather events in all port facilities.
- Equipment with modern marine pollution risk assessment systems.
- Shift to digital innovation using technologies, such as artificial intelligence, big data and blockchain.
- Training the human resources of ports in the new digital technologies.
- Formation of the necessary conditions so that all Greek ports gradually receive EMAS or ISO 14001 certification for their proper environmental management.

- Drawing up plans to deal with marine pollution and waste management in all ports, in order to be able to implement the existing legislations.
- Drawing up plans to monitor and improve air quality inside and outside ports, with the installation of air pollution monitoring, sampling and reporting stations.
- Establishment of policies for the sustainable development of ports.
- Better connection with other means of transport, especially with the railway network, for the channeling of containers both in our country and others.
- Establishment of a scientific research group for the preparation of a study on alternative marine fuels.
- Construction of infrastructure for the supply of electricity from land (Cold Ironing) and facilities for alternative fuel supply (hydrogen).
- Installation of solar panels on land facilities and wind turbines in unused port areas (e.g., breakwaters) in order to cover part of the port's energy needs.

6. Conclusion

Ports have always played a pivotal role in societies, providing them with many social and economic benefits. In recent years, the port industry has faced continuous changes due to social, economic and technological developments in the modern globalized environment. This fact has led to the need to modernize port infrastructure and operations in order to ensure their ability to maintain a competitive edge in the market. In this direction, port administrations are turning to the adoption of new methods to ensure economic efficiency and, at the same time, protection of the environment.

Several ports worldwide have turned to smart technologies, in order to become more efficient in the global shipping industry. In addition, the need for environmental protection and sustainable development are an immediate priority for the port industry in order to deal with the climate change and the energy crisis that takes place on a global scale.

Greece is a country with many ports of various sizes that is a commercial crossroad in the Mediterranean, yet Greek ports are far behind in the use of smart technologies and environmental protection. However, the location and geophysical wealth of our country are important advantages that could make Greek ports important transport, trade and energy hubs. In order for this to happen, the adoption of appropriate policies and actions and the active participation of all stakeholders is considered necessary for a smooth transition to the new era with main focus on environmental protection.

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