
Physical and Technological Infrastructure and their Role in the Sustainability of Marine Ports

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Abstract: Shipping is considered as the most efficient mode of transport in economic and environmental terms. Due to economies of scale, it can offer the lowest cost per ton-km transported, However, its impacts on climate change through greenhouse gas emissions and on human health from air pollutants released near residential centers cannot be ignored, Nikitakos (2012) proposes the zero-emission port where any energy consumption within the port's operations is to be covered by in-port renewable energy sources (RES) generation, for example wind turbines , Ports Should Plan and Manage their Operation and Expansion in a Sustainable way to Decrease the environmental Impacts. And on the other side, factors of production are the inputs needed for the creation of goods or services. The factors of production include land, labor, capital and entrepreneurship. Technology, in addition, plays an important role in influencing production nowadays . Increasingly, technology is responsible for making a difference between companies. this paper aims to clarify the importance of sustainability in maritime ports and how to implement this concept through the physical and technological infrastructure linking with the fourth industrial revolution in the development within the ports and giving some examples of international best practices that have been implemented in such successful maritime ports. This will have its impact on supporting Arab ports to which will lead to increase efficiency in these ports as well as to economic growth

Key words: Sustainability, I4.0, Infrastructure, Ports, Digitalization

Introduction: 50% of the world’s population live in coastal zones, while 92 % of global commerce relies on maritime (Mark E.Luther, 2017) The United States has 360 general commercial ports through which America's trade is transferred internally between the states and externally with other countries. 99.4% of America's trade is exported through seaports. (NAC,2014) Directives of the European Union are focused on the “green” development of seaports, where the major focus is on environmental protection and the energy efficiency. As indicated in the port and maritime EU directives, the concept of the Europe’s ports is crucial to the European economy due to the fact that they act as gateways, linking its transport corridors to the rest of the world. With 74% of goods entering or leaving Europe to go by sea(Docksthefuture.2018),ports are also important for support economic activities since they act as a crucial connection between sea and land as a supplier of jobs, seaway transportation is the cheapest and most effective transportation system compared to other ways. (Norcliff, et al ,1996) pointed out that “ after the second world war ports created cities, and big ports created big cities “. Economic growth in ports must be balanced with environmental protection and social progress. This has led to enhanced appreciation of the need for sustainable development (SD) in ports, Ports usually have their own infrastructure including, the first part which is Landside consist of Berthing structure, crane rails, bollards, hand rails, guardrails, lighting, power supply, raw water supply, water drainage system, sewage disposal, administration building offices, warehouse, storage, Bridges and rail, the second part is seaside consist of port channels and harbor basins, (Daniel Kong ,2013) Ports work through the activities that provides to attract individuals and companies such as distribution centers, warehouses, freight agents and logistic companies. All of this would stimulate economic growth, sure there is an impact resulting from port activities that affects water, air and the environment in general, so developing the port in a sustainable way requires some objectives and Policies (Jasmine&wei, 2019)

Exhaust gases are the primary source of emissions from ships. Carbon dioxide is the most important GHG emitted by ships, both in terms of quantity and of global warming potential, other GHG emissions from ships are less important, Under MARPOL Annex VI, the global sulphur cap for fuel oil used on-board ships is reduced to 0.50% (from the current 4.50%) from 1 January 2020, and particulate matter are 1.00%, and further reduced to 0.10%. (IMO,2020) Air pollution in ports is the

result of vehicle and cargo movements (ships, cargo handling equipment) and has both local and global consequences. Various different pollutant types are emitted, some of which affect the local air quality, while others are climate change forcing agents. Currently dealing with air pollutants is the most pressing issue port authorities, shippers, and regulators are trying to address with the majority of existing policies and port initiatives, A number of port authorities are upgrading their cargo handling equipment with the introduction of faster and more efficient machinery. This has positive effects in the energy efficiency of the terminal and at the same time reduces the turnaround time of vessels at berth and thus the vessel emissions generated near the port , On yard operations, the main environmental benefits will come from the deployment of more efficient ship to shore cranes that will increase the number of moves per hour and thus reduce the total turnaround time of large polluting vessels. At the yard, replacing handling equipment running on diesel fuel with hybrid or electric machinery will greatly reduce emissions at the yard (ZIS T.,2019)

Research importance

The importance of this research due to the increase in pollution resulting from the activities related to marine ports , and its negative impact on workers and surrounding areas, the attention that IMO pays to reducing emissions of sulfur dioxide, carbon dioxide and greenhouse gas, and the lack of adequate attention would cause a major threat, whether to the marine environment or to human health , As well as the importance of the technological transformation of the procedures or the activities that takes place inside the marine ports by using big data and (IOT) and all related technologies to keep pace with the fourth industrial revolution which reducing vessel waiting time which accordingly minimize costs whether for the port authority and for ship and cargo owners.

Research objective:

The Study Has the Following Objectives:-

- 1- To know best practices for marine ports sustainability.
- 2-To identify stakeholders who have an impact on the port community.
- 3-to know the importance of shifting to use technology in all processes and procedures within the port.

4-determine best partnerships took place between port authorities and technology companies to develop port processes and technology transfer.

Research problem:

Due to the intense competition between ports to attract shipping lines and various investors, Despite the excellent capabilities of Arab ports , However most of Arab ports did not give enough attention to the sustainability of marine ports.

Research Methodology:

The researcher collecting data based on literature reviews, data, statistics published in the websites of marine ports and personal interviews with specialists in marine ports.

Sustainability: Definitions of sustainability vary between international organizations and countries, In June 2015, UN set 17 goals for sustainable development from 193 countries with 3 dimensions, social, economic and environment. Economic development has been identified in Goals No.8; 9 for industrialization and Goal No.1 to reduce poverty by increasing employment rates and structural transformation towards industrialization and promoting innovation and technological upgrading by focusing on sectors with high added value . The ninth goal reflects the need for resilient infrastructure (ESCAPE,2016) A number of European countries announced a strategy for sustainable development. Some examples are Norway in 2003; Switzerland in 2004; UK in 2005; Sweden in 2006.there are consensus that all these countries and organizations need to achieve progress and prosperity for all generations. Although these indicators differed, but all of them are based on three main dimensions, namely the economic, social and environmental dimensions (Thorvald Moe, 2007) Sustainable development has emerged as the guiding principle for long-term global development. Consisting of three pillars, sustainable development seeks to achieve, in a balanced manner, economic development, social development and environmental protection(docksthefuture,2018), (AAPA 2007) define Port sustainability as “business strategies and activities that meet the current and future needs of the port and its stakeholders, while protecting and sustaining human and natural resources”

Actually we have to define and determine stakeholders to avoid the conflict of interests in the long term planning.

Stakeholders: (Notteboom & Winkelmann, 2002) divided the Stakeholders into 4 groups

a) **Internal:** Board of Directors, employees, shareholders, unions. b) **External:** terminal operators, shipping companies, unloading carriers, freight agents, factories inside the port, ship maintenance, import source, c) **Public policy:** Ministries and agencies d) **Community:** Civil Society Organizations, Media and Press, Population.

(Lam & Van, 2012) divided stakeholder into four groups,

a) **market players**, shipping companies, b) **Public policy makers:** Port Authority, Ministries c) **community**, residents and nongovernment organizations and d) **Internal stakeholders** Employees are the first stakeholders, they have a significant impact on the success of the port's transformation into a green port, so their education and awareness is important to success in many areas such as waste management and energy saving. In a similar manner, (Jasmine & Wei, 2019) divided them into four groups as follow:

1-**Internal stakeholders:** employees, shareholders, managers and owners,

2-**The public sector:** Port Authority, Ministries "Transport, Finance, Environment, Justice" and Workers Unions

3-**Companies:** transport companies and loading and unloading companies

4-**Community;** interest group like (residents; consumer; non-profit organizations and media)

After we have defined the stakeholders for port community, we have to know their importance and influence, interests and strategy plan. These all have a lot of advantages to the success of port planning for sustainability and hence conflicts can be avoided. This gives the planner a first overview about important stakeholder groups and possible problems he has to deal with, and finally facilitates planning (Elkington, 1997). In order to achieve sustainability, you have to involve stakeholders. (Anderson & Brodin, 2005) pointed out the importance of involving the customers when setting the sustainable goals (ESCAP, 2016).

One of the most important stakeholders are knowledge centers. The role of the knowledge centers, mostly the universities and research institutions, are very unique among the above-mentioned stakeholders since

approaching the Port of the Future concept requires new initiatives, innovations and solutions to support the current port challenges (Docksthefuture,2018)

Communication with all stakeholders is the most important factor for sustainable development. Successful ports did not depend on regulation requirements only but also on input from multiple stakeholders. Reconciling differences between various stakeholders, public-private partnerships, and policies negotiated by consensus can foster port sustainability.

Here we can explain one example to identify the power of stakeholder and how they can affect on the decision makers. Resolution no. (488) of 2015 and Resolution no. (800) of 2016 were issued to raise port dues. As a result some shipping lines left the Egyptian ports to Greece port to avoid the raises of dues. After that the Suez Canal economic zone issued a resolution no. (121) of 2018 reducing port dues up to 60% to attract the shipping lines again.

Sustainable Development practices:

- The approach taken by the state of New Jersey since 'Sandy' has become a major force is the formal adoption of the most stringent design and construction standards for coastal areas (Thomas Wakeman et al, 2015)
- Antwerp provided electricity for ships. Onshore power supply scheme by which ships get electricity on shore. (ESCAPE,2016),
- In 2007, POLB launched the CTP that bans diesel trucks built 1998 or earlier from serving the port. Truckers can apply for subsidies to finance truck replacement, for which POLB collects a fee. The fee is waived for privately-financed clean trucks (CCJ, 2009a).
- Meanwhile, POLB has subsidized the purchase of trucks with liquefied natural gas (LNG) engines (Cannon, 2009; Quinn, 2007). While these trucks cost almost twice as clean-diesel trucks (Mongelluzzo, 2009b), an LNG truck can save between \$0.35 and \$1.73 per gallon (Cox,2009). However, because 2010-model diesel trucks will be 98% cleaner than pre-1989 diesels,
- The LB PORT create The Green Flag program provides approximately \$2 million a year in discounts and environmental recognition for vessel operators who slow their ships to 12 knots (22 km/h) or less within 32 km of the harbour, thereby reducing emissions (POLB, 2011f; Quinn, 2007).

- POLB has built new infrastructure to provide shore-side electricity (also known as cold-ironing) to container ships (Dibenedetto, 2004; POLB, 2011g). Shore-power allows ships to shut their diesel engines at berth and plug into landside electricity grid to improve air quality
- The US and Canada have proposed the world's largest emission control area. California has established its own emission standards to introduce these limits far sooner than the timetable proposed for the North American emission control area (Wallis, 2009a).
- Los Angeles Port reduced by 77% Matter emissions And nitrogen oxide 56%, by using high-quality diesel for goods transport equipment to reduce emissions and increase green areas in the port(NAC,2014 ; Jasmin&wei,2019)
- LNG-fuelled vessels pay lower tariffs in Singapore , while there are plans of the European Commission to develop LNG bunkering services in all EU ports within the Trans European Core Network by 2020 (European Commission 2013).
- in Singapore reduced port fees are required for ships that are using low-sulfur fuel or have good scores in their Energy Efficiency Design Index (EEDI),(Zis T.,2019)
- The Port of Gothenburg in Sweden has two ferry (Ro-Ro) terminals with cold ironing capabilities. Shore power is supplied by local surplus wind-generated power and is marketed as a zero-emissions solution. Ferries have in general lower electricity requirements compared to other types, mainly lighting and ventilation during loading/unloading of vehicles (Zis and Psaraftis 2017).
- .The port of Antwerp has provision for seven onshore power connection points at one terminal, for barges. In Hamburg, LNG barges are deployed that provide power to vessels at berth.(ZIS T.,2019).
- in 2017, Damietta port IN Egypt supplied 4 vessels on the berth with the necessary electricity instead of using their diesel engines as they were left on the dock,(DPA,2017)

While incorporation of some sustainability elements can increase initial costs, they can yield substantial life cycle saving resulting from lower energy and water consumption and wastewater, lower operation and maintenance costs and benefits from increased productivity.

Technological Infrastructure: Ports authorities will not be able to achieve sustainability through the adoption of best environmental practices and procedures, but also the adoption of best practices with technological systems that help in achieving welfare and prosperity. Currently, the largest companies are no



longer the largest in size or most productive companies, but they are the most advanced in technology such as Apple, Ali Baba, Amazon, Google, Microsoft and Facebook. Thanks to the emergence of technologies and the exchange and processing of information and data in a faster, more efficient, and cheaper manner, this leads to efficiency in production and ease in decision-making (Dr.Eric, et al.,2018). Innovation in technology leads to economic growth and creating opportunities for work and prosperity along with efficiency in the use of energy and resources. But this development may lead to a risk that may arise due to the inability of low-income countries to succeed in global competition on this industrial performance if these countries are not able to create an economy equipped with fourth industrial revolution (I4.0) and a highly skilled workforce. Technological innovation is a driving force for economic prosperity, but we find that every new wave of industries creates unemployment for a decrease in demand for old skills and an increase in demand for new skills. Of course, this led to comparative advantages for developed countries, while other countries were not able to adapt quickly enough to the new requirements. The result was economic growth for these countries and weakness of other countries. Accordingly, many countries have created plans for industrial development to keep pace with global development and global competition and take a permanent place for their country in the global industrial and investment competition.

Table (1) Different Vision of Developed Countries

Country	year	vision
GERMANY	2011	(industry 4.0)
USA	2011	(industrial IOT)
ITALY	2012	fabbrica intelligente
UK	2012	High value manufacturing
Sweden	2013	Production 2030
Korea	2014	Manufacturing innovation3.0
Netherlands	2014	Smart industry
Japan	2015	Society 5.0
France	2015	L’industrie du future
Spain	2016	Industria conectada 4.
Check	2016	prumysl
China	2015	Made in china 2025
Singapore	2015	Singapore industry 4.0
Thailand	2016	Thailand 4.0
Mexico	2016	Crafting the future

(Markus springer, Judith schnelzer,2019)

Germany is currently the leader among countries that supply factory equipment, including mechanization and technology. In 2016, the percentage of employees working in production and manufacturing reached 27.9% of the workforce in Germany 16.9% of exports in high technology started focusing on specialization support and high tech manufacturing markets and the support was targeted only to small enterprises, producers / manufacturers (Markus Springer, Judith Schnelzer, 2019) When we see the transformation that took place in some seaports from keeping pace with high technology and using it to develop their performance inside the ports and achieve sustainability, we can take Rotterdam port as an example. The port developed its plan to be the smartest port in Europe and the world.

- **Port of Rotterdam:** 90,000 employees work at the Port of Rotterdam and contribute 10.5 billion euros, equivalent to 3.3% of the total GNP for the Dutch economy and in 2017 the World Economic Forum announced for the sixth year respectively that the infrastructure of Rotterdam port is the best in the world. They cooperate with IBM using IOT cloud such as tracking ship movement, weather and water depth data. The port processes more than 140,000 ships. Any ship has deal with multiple parties. However, the port authority uses **digital dashboard** to view the operations for all parties at the same time which enables the port to dock more ships every day and reduce the cost for the ship owners. This leads to minimizing the waiting time. Another technology is using **3D printing** R & D in shipyards. This has been established to ensure the presence of spare parts of consistently high quality and at a competitive price. After that, a laboratory was established for 3D printing for the port and the shipping companies and provides all metal spare parts for ships upon request and as soon as possible after they used to take 6-8 weeks. This can now be done within 200 hours to provide spare parts (IBM, 2018). The maritime industry has developed some potentially important technologies that are mentioned below and could help in changing the future in the maritime industry.
- The Autonomous boat Called (sea-kit) with a length of 12 meters left southeast England to deliver a box to the port of Ostend In Belgium after 22 hours a box was delivered to the Belgium Customs.
- Rolls-Royce participate in an alliance to create a trans-ocean Autonomous ship by 2035

- the Norwegian shipbuilding company Vard and Kongsberg company are currently working on building the first fully-fledged and containerized electric vessel to be in operation next year (Weforum, 2019). The ship was supported by the Norwegian government with 133.6 million Norwegian krone, while the ship cost 250 million Norwegian krone (Kongsberg, 2018).
- The port of Amsterdam for example, has launched multiple apps. The I Am Port app offers real time information on ships locations and itineraries in the port. In addition, you can find information on arrivals and departures, size, draft and berth of each ship in the port. A second app, the Port Data app shows the historical market shares of the throughput of cargo of eleven ports in the Le Havre – Hamburg range in order to promote the idea of data sharing. Finally, a third app allows to tour the port aiming to increase local support for the seaport (Deloitte, 2017).
- Rolls-Royce has signed a deal with Google to further develop its intelligent awareness systems which are making existing vessels safer and is essential to making autonomous ships a reality. It allows Rolls Royce to use Google’s Cloud Machine Learning Engine to further train the company’s artificial intelligence-based (AI-based) object classification system for detecting, identifying and tracking the objects a vessel can encounter at sea.
- BAE Systems Australia plans to transform Australia’s shipbuilding industry to a digital shipyard in Adelaide.
- Inmarsat, a global mobile satellite operator has launched a new service in partnership with Samsung Heavy Industries, called Smart, designed to allow commercial ship owners to enhance efficiency by harvesting data from hull monitors and equipment sensors onboard in real-time, via Inmarsat’s dedicated bandwidth for Certified Application Providers.
- Kleven Industries in Norway, has invested in new robot welding systems that are precise and can work 24 hours a day and also South Korea has the same technology, (Malaysian Industry-Government Group For High Technology, 2018).

Conclusion

Sustainable development requires ensuring that ports operate efficiently. Existing available infrastructure and the technology used must be optimized, maintained and modernized. Identification of the need for

new infrastructure must be done before losing their position in global competition race, the fiscal and technological infrastructure are driving forces for sustainable growth, so the port authority has to involve other stakeholders to enhance their long-term plans. To be sufficient and sustainable, the following points must be taken into account:

- The sustainability plans is a dynamic effort requiring flexibility and continuous improvement.
- Linking with policies, The plans must comply with laws and regulation for the country.
- Reducing the number of sustainability indicators to be more effective and controllable.
- The presence of a SD committee to monitor and review to apply an appropriate intervention.
- Using internationally comparable indicators
- Achieve a win-win situation among all stakeholders to ensure long-term sustainability goals achievement
- The use of modern technology; not only to increase productivity but also to increase safety and security.
- For the Environmental aspects, it is possible to raise fees or impose taxes whenever the pollution rate increases. This forces companies to reduce their pollution.
- Provide skilled human capital, especially in the fields of science, technology, engineering and mathematics, and establish research and development departments to enhance the innovation
- Ensure the provision of the necessary infrastructure, such as high-speed internet, to facilitate processing and analyzing of data in a fast and efficient manner.
- Providing incentives to those adheres and committed to implement sustainability terms.

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