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# Contribution to the implementation of “Green Port” concept in Croatian seaports

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## ABSTRACT

The port systems have been identified as major energy consumers. They represent the systems that have difficulty in the adaption of innovative solutions with regard to energy savings and energy efficiency. The most of port systems are using the outdated technology for the measurement of energy consumption and because of the mentioned facts they do not contribute to energy efficiency, environmental protection and sustainable development. On the contrary, seaports are one of the main drivers of the pressure on the environment, especially because of the fact that most of the seaports and terminals are located close to the urban areas (city areas). This paper presents the proposals relevant for the transformation of seaports into environmental friendly ports, based on the “GREEN PORT” DEVELOPMENT project proposal, which is submitted by the Intermodal Transport Cluster (Croatia), on Adriatic-Ionian Programme INTERREG V-B Transnational 2014-2020. Some proposals require advanced technology and resources, while others, such as, thimplementation of the so called model of “Green Port” development do not require any special skills. These proposals represent a small contribution to the great effort to energy efficiency, environment protection and sustainable development.

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## 1 Introduction

Nowadays, seaports provide numerous services which are mostly related to passenger and cargo transport. Shipping is responsible for approximately 20% of global discharges of wastes and residues into the sea. The busiest the port is, the higher are the risks for suffering from pollution in those ports. On the other hand, port is a conventional word which includes conflict between human act and environment, so they represent a danger to environmental protection. However, the experience has shown that even in the best kept ports and terminals they do occur. For that purpose, oil separators of different kinds, oil booms and skimmers are used to salvage the damage. Thus, the overall objective of this project is to support marine environment protection and modernisation of waste management system and facilities in seaports which are one of the methods for establishing the so called “Green Port” development. Economic growth and environmental protection are regularly considered and interpreted as

two separate, possibly conflicting areas. New concept of a sustainable “Green growth” assumes a positive synergy. This new paradigm of “Green growth” can be considered as an opportunity rather than a threat. While in the past, the main drivers were labour and capital, sustainable “Green growth” focuses on new ideas, innovations transition even in the process of technological development [5]. Embracing the “Green” development as an economic actuator will benefit the port and port authorities as it will improve their economic, commercial and operational activities, which also contribute to the development of the overall economy of the countries involved in the above-mentioned project.

Directives of the European Union are directed to the “green” development of seaports, which implies a special attention to the energy efficiency and environmental protection. It can be said that the concept of a “green” and sustainable development are identified as mutual dependence. Furthermore, transportation is inevitably a question related to the concept of “green” development and sustain-

ability. In particular, it relates to seaports, as an important hub of transport networks. In maritime transport, emphasises are on the use of the interdisciplinary approach that requires a combination of modern technology, research, education and environmental protection activities following the legislative framework of the European Union. The rapid development of port technology and operations has led to the alarming need for the strengthening of the port environmental management and energy efficiency systems. Emphasis is on the environmental issues related to the ship operations, cargo handling operations, infrastructure projects related to the expansion ports terminals, port hinterland connections, etc. On the other hand, the provision for an adequate port capacity and a quality of port services is essential for seaports economic benefits. The question that arises can be how to strike a balance between economic interests and environmental impacts in order to achieve sustainable growth and development of port systems and port areas (gravitated port cities). The concept of "Green Port" development has evolved from research activities focused on the sustainability of all activities related to maritime affairs. The concept of "Green Port" development indicates a sustainable and environmental friendly seaport.

## 2 The implementation of measures relevant for the concept of "Green Port"

The concept of "Green Port" development is the integration of the environmental friendly method of port activities, operations and management. There are several ways to define measures for the establishment of ecological/green seaports. Examples of measures are: the implementation of policies relevant for the reduction of the emissions of harmful substances into the atmosphere, the landscape design of an appropriate seaport which includes trees that absorb noise and pollution, etc. Moreover, meas-

ures include the use of renewable energy port operations and activities, recycling and reuse of materials. One of the main measures for the application of the concept of "Green Port" development is the inclusion of the term "green" growth in the further development of the port systems and the establishment of environmental planning within the mentioned areas.

### 2.1 Overview of studies and proposal measures of the world's researchers

Seaports are connecting world through the maritime transport network. They promote international trade and support the global economic growth. However, seaports are the most common point of entry of anthropogenic environmental pollution through the activities of maritime transport. That is a critical challenge for port managers who strive towards providing efficient port protection services related to the environmental protection [3,401].

The environmental concerns regarding the port systems are very diverse. They can arise from maritime activities, internal port operations, warehousing and transshipment of transport activities within the port area, etc. The increase in transport activities increases also the CO<sub>2</sub> emissions and represents potential threats to serious environmental pollution. In recent years, a major priority is to minimize the harmful impact of port operations to the environment. Seaports are trying to achieve a "green" status by introducing new technologies and renewal systems for energy production in the port infrastructure. Therefore, the model of "Green Port" development is an important concept for the development and operation of the port companies to prevent environmental degradation, loss of biodiversity and achieve a sustainable use of natural resources.

The so called model of "Green Port" development is based on three aspects of work and port systems plan-

**Table 1** Evaluation of Environmental Priorities in the European Port Sector in the 1996-2013 Period of Time

No.	1996	2004	2009	2013
1.	Port development (water)	Port waste	Noise	Air quality
2.	Quality of water	Dredging operations	Air quality	Port waste
3.	Dredging	Dredging operations	Seaport waste	Energy consumption
4.	Dredging operations	Dust	Dredging operations	Noise
5.	Dust	Noise	Dredging operations	Waste from the ship
6.	Port development - landside	Air quality	Relations with the local community	Relations with the local community
7.	Landside pollution	Danger cargo	Energy use	Dredging operations
8.	Habitat degradation	Storage	Dust	Dust
9.	Amount of traffic	Port development - landside	Port development - water	Port development - landside
10.	Industrial wastewater	Discharge of ship's bilges	Port development - landside	Quality of water

Source: <http://www.ecoport.com/publications> (10.05.2016)

ning that include energy conservation, environmental protection and environmental care. The idea of developing “Green Port” should be converted into activities. The mentioned activities should be exercised on the basis of factors that have an influence on the definition of the concept of “Green Port” development. The European Seaports Organization (ESPO) has followed the environmental priorities in the European port sector since 1996 through regular surveys. Table 1 displays the change in priorities from 1996 to 2013.

Priority areas have changed their ranking over time, but some parts retained their importance for the sector. Environmental problems that are constantly occurring over time are colour-coded. Air quality is displayed as the current environmental priority by the European port sector as a whole. This reflects the priority given to issues relating to the health of people who work or live around the port areas, and is in line with the European political plan revision of the EU policy on air quality and several initiatives that aim to control emissions discharge of pollutants from ships into the atmosphere. Waste management/port management remains a high priority to environmental protection in the port sector, while waste from ships entered into the top 10 priorities for the first time, probably as a result of the ongoing review directive on port reception facilities for waste. Power consumption has been a new priority since 2009, while the management holds a high level of noise among the priorities. Some of the environmental issues such as dredging, dust and port development are constantly appearing in the top 10 priorities of the European seaports in the last 17-18 years. Finally, water quality appears again in 2013 in the top 10 priorities [6, 2].

According to a study conducted by the OECD [4, 19], a well organized port can play an important role in the promotion of economic development in the surrounding areas and wider hinterland. Of course, port activities can have a negative impact on the environment. The transport of cargo by sea can cause hazards to the environment in the port and its surrounding areas. Examples of the negative impact are noisy marine engines, machinery for loading and unloading cargo, releasing harmful particles, CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> from the ship's main and auxiliary engines and dust while handling the materials such as grain, sand and coal. Road and rail traffic from the port area cause additional environmental problems. In general, the impact on port environment can be divided into three sub-categories: (1) problems caused by port activities, (2) problems caused by the ship sailings, and (3) emissions from intermodal transport network in function of serving the port hinterland [1, 3]. Referring to the report of the American Association for the Port Authority, Bailey and Salomon [2] pointed out that due to the fact that seaports are often located near residential communities, urban areas and/or environmental sensitive areas the following environmental problems have been most frequently mentioned: (1) air pollution from port operations, including smog and particle pollution, (2) the loss or degradation of habitat,

(3) destruction of fisheries and endangered species, (4) wastewater and rain water discharges, (5) traffic congestion, (6) noise and light pollution, (7) loss of cultural resources, (8) contamination of soil and water from leaks from different tanks, (9) air pollution from chemical storages, (10) solid and hazardous waste pollution, (11) runoff and soil erosion [1, 3].

Furthermore, several studies have been carried out in order to enable seaports to select control measures and environmental management priorities relevant for defining the indicators in function of the development of “Green Ports”. Authors Chiu and Lai have identified 12 types of measures relevant for the realization of the “Green Port” model. These measures can be classified into five dimensions, including environmental quality, energy use and resources, waste management, quality of habitat and vegetation, as well as participation of the society. A supplement to the mentioned measures has been further described by the authors: Chiu, R. H., Lin, L. H. Ting, S.C., in the paper entitled “*Evaluation of Green Port Factors and Performance: A Fuzzy AHP Analysis*”. By using the AHP method, detailed measures and actions that port authorities need to do for a systematically conversion into the so called model of “Green Port” have been defined,

## 2.2 The adoption of the concept of “Green Ports” in the further development of seaports

A “Green Port”, also known as an ecological port, represents the model of a sustainable port development, which not only meet demands of the environment but also increases the port's economic interests. The concept of building a “green port” should be set as a priority in the construction of harbours and coastal areas. Furthermore, it is necessary, within the port management, to include and implement the concept of “green ports” in ports development planning. From a development perspective, environmental resources are scarce, but they make up the basis for an economic development. Therefore, the inclusion of the concept of “green ports” in ports development planning requires a coordinated distribution in phases according to current possibilities of seaports. As already mentioned above, the inclusion of this term in ports development planning is significant for technological improvements in the production of energy efficiency (technological innovation, new innovated equipment, etc.) which enables the coordination of environmental protection and sustainable economic development.

## 2.3 The establishment of environmental planning in seaports

Environmental planning management plays a significant role in determining directions in the construction and development of seaports. Planning is a proving performance of individual reconstruction, such as the possibility of reconstructing the existing wharfs, new construction with innovative solutions, application of innovative and

advanced technologies, etc. Activities mentioned above reduce the pressure on the environment in the process of economic development. Through the scientific and operational planning of the environment, the balance between ecological capacity and economic development can be reached. After the establishment of environmental planning, it is necessary to investigate the ecological status of ports and its resources. It is also important to establish the database related to the achieved ecological and energy efficiency situation in a seaport.

Seaports environmental planning is the key for a sustainable development and the efficient management of environmental components directly associated with the future implementation of the sustainable ecological development of seaports and its surrounding areas. Therefore, it is of utmost importance to strengthen the environmental management and integrated awareness of port authorities related to the environmental protection. Through various activities, port authorities are trying to achieve the coordinated development among economic, social and environmental benefits. One of these activities, the previously mentioned environmental management plan, is in function of reducing the emissions of waste generation and in adapting its services to the demands of the market.

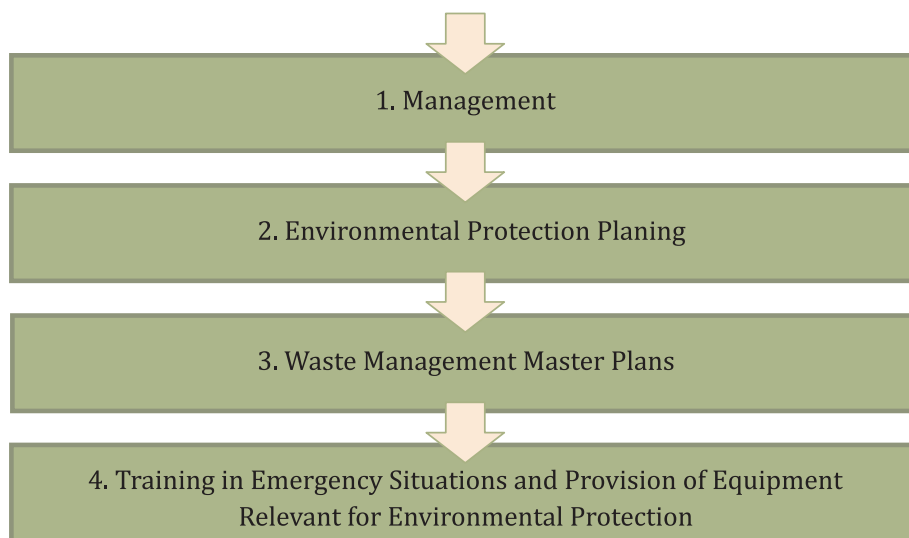
Measures of transforming the seaports into the so called model of "Green Port" are numerous. It is important to take such measures as to achieve a balance between ports, transport and transshipment activities, storage activities, human needs and the environment. All the elements related to the construction and operation of seaport activities should be focused on the efficient use of resources, minimization of negative impacts on the regional environment, raising the level of environmental management and

improvement of environmental quality in seaports and its surrounding areas.

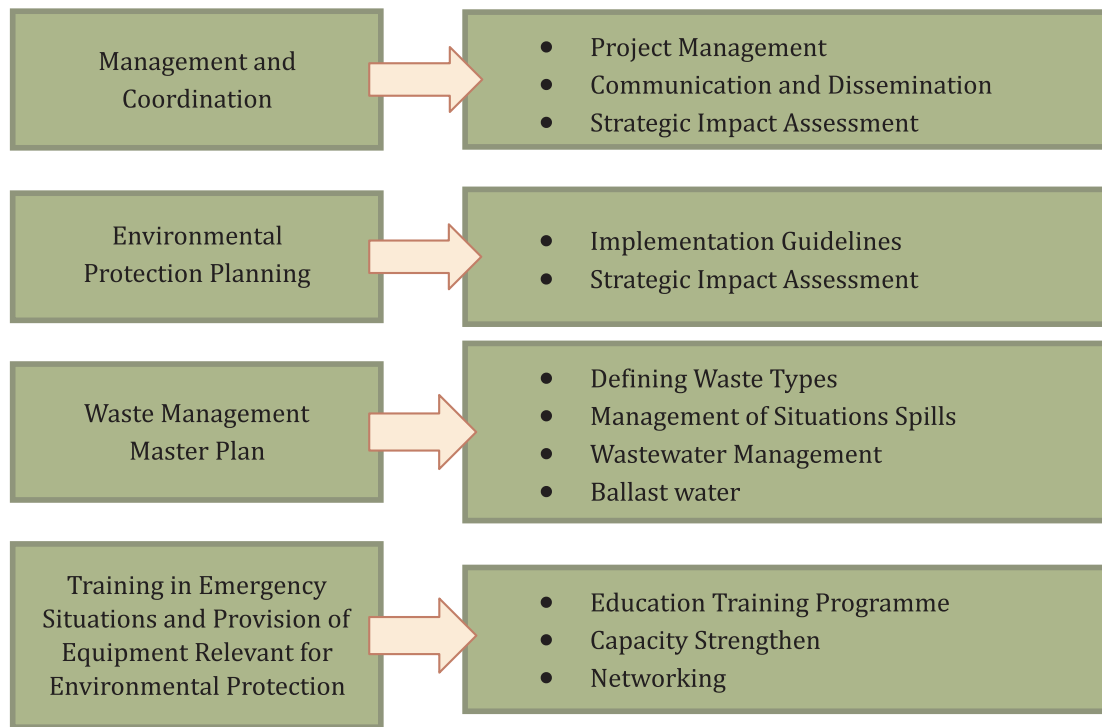
### 3 The process of introducing "green" port development in Croatian seaports

Based on the previously described research in chapter two, a general model relevant for the implementation of the concept of "green" port development has been created. The main activities of the proposed theoretical model related to the analysis of the current situation of environmental protection in the Croatian seaports refer to the definition of the Master Plan. The Master Plan defines the conditions of purchase and installation of the equipment relevant to the implementation of the environmental protection system. These activities include the creation of a particular information system and a test in real conditions. The analysis refers to the state of the infrastructure, the implementation and training of responsible internal staff. The Master Plan needs to define the waste management system in the Croatian seaports.

Since the "Green Port" concept can be realized through different methods of integrated environmental protection, the implementation of activities of this model highlights the basis of the idea of "Green Port" concept. The model can be considered as an effective use of resources in the function of reducing the negative impact on the seaports environment and its surrounding areas. Furthermore, the model has an impact on the increase of the efficiency level of the seaports environment management through the improvement of the quality of the natural environment of the seaports and its surrounding areas. The theoretical model can be divided into several relevant criteria which consist of a set of defined activities (Scheme 2).



**Scheme 1** The Theoretical Model of Introducing the "Green Port" Development Concept



**Scheme 2** Theoretical Criteria Model and Its Activities

Source: Authors

### 3.1 Management and coordination

This criteria is aimed at ensuring the proper implementation of the work plan defined by the Master Plan of development of the so called “Green Port” concept. Mentioned can be done through the steering committee established of the stakeholders observatory and through the network of the sea port and/or port authorities managers and other internal or external staff involved in the implementation. Relevant decisions which need to be coordinated are issues such as: financial and administrative plans, monitoring and prioritizing activities, problems affecting project implementation, etc. The communication and dissemination activities need to be targeted on: sector stakeholders, local, national and international institutions, with a particular reference on the decision-makers, general public, focusing on the increased sustainability of seaports system solutions.

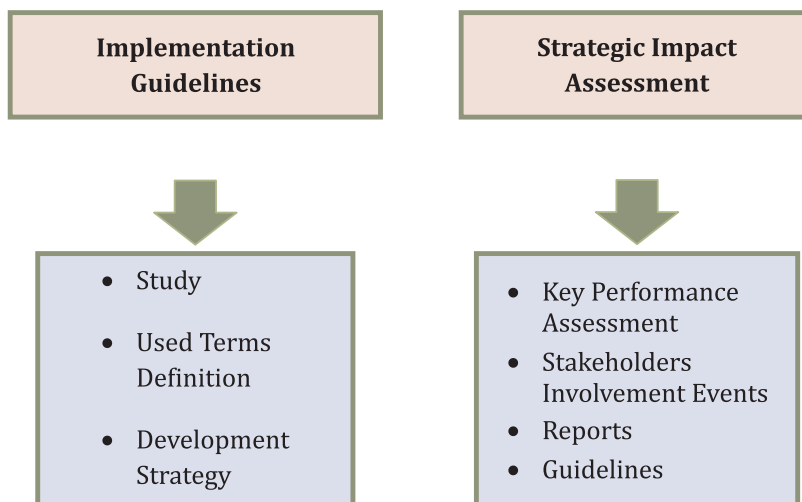
### 3.2 Environmental protection planning

In order to achieve the objectives related to the concept of “Green Port” development, the need for proper planning activities is the most important one. In other words, there is a need for the introduction of the quality environment management planning systems in seaports, the basis of which is the implementation of the Strategic Environmental Port Assessment with particular emphasis on waste management and pollution opportunities that arise by seaport and vessel activities.

Scheme 3 shows the output results of the activities related to the Implementation guidelines and Strategic Impact Assessment.

The goal of this activity is to define and set issues which need to be resolved and related to the existing situation in seaports and its surrounding areas. It is also very important to include interested stakeholders in the activities and in the implementation of the Strategic Environmental Assessment which will result in the definition of strategic guidelines for the future concept of the “Green Port” development. In order to reach the goals of the “Green Port” concept, there is a need for a proper planning activity. In other words, there is a need for the introduction of environmental planning into ports. This will lead to environmental quality management. The overall objective is to carry out a strategic environmental assessment of ports with a special focus on waste and possible pollution caused by port activities. The assessment needs to be based on a detailed indicator system and needs to consist of: (1) Situation Assessment (2) Opportunities and Constraints (3) Future recommendations. The whole process needs to be based on strong stakeholders/target group involvement. In order to reach the mentioned goal, it is relevant to identify the key stakeholders and then organize meetings and workshops to pass the message of the “Green Port” vision to them and to share and exchange the strategic issues of the assessment. Finally, all documentations will be sent out for the stakeholders’ review. The final result will be the elaboration of guidelines for their implementation on the end users.





**Scheme 3** Defining the Guidelines of Implementation and Strategic Assessment

Source: Authors

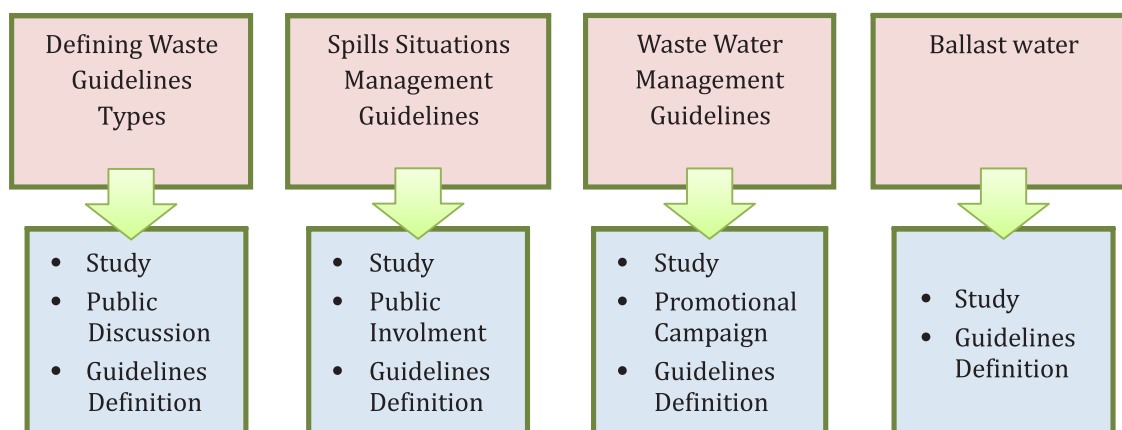
### 3.3 Waste management Master Plan

The objective of these criteria is the development of a Waste Management Master Plan, which will summarize the issues on the international level and will solve problems related to waste management in seaports and its surrounding areas. The Master Plan will also define and offer unique and effective solutions relevant for the ecological efficiency in seaports and its surrounding areas. The Master Plan is the most important instrument for achieving the mentioned objectives, because, in the implementation of the so called “Green Port” development model, a special attention will be on the following issues:

- Oil from vessels,
- Bilge water from vessels,
- Waste from vessels,
- Waste water from sewage,
- Ballast water,

- Pollution caused by vessel paints repair,
- Waste related to the maintenance of the port infrastructure and superstructure,
- Contaminated material from dredging.

The Master Plan must be based on the reports and on a detailed analysis of the existing strategies and the regulatory framework of waste management of those countries where ports already have a “Green Port” concept. The Master Plan will examine all possible aspects of the “Green Port” vision and will define guidelines related to the methods relevant for each local conditions. The goal is to create a summary of the measures and methods of waste management in seaports related to the observed categories of contamination and to define the model of implementation. One of the elements for achieving efficient environmental protection and sustainable development of seaports and its surrounding areas will be also mentioned. Scheme 4 shows the outputs of activities within the waste management.



**Scheme 4** Waste Management Outputs Activities

Source: Authors

This activity aims at analysing and evaluating the necessary measures to define the proposals in the event of urgent environmental interventions (oil spill). What need to be discussed and examined within those activities are adequate reception facilities for waste, regulatory frameworks and proposed guidelines to avoid/minimize the effects, possible procedures to be applied in sensitive maritime areas. Accordingly, the study needs to be done with the purpose of analysing the best way to accept and reserve waste. Through the organization of an open discussion such as a forum with environmental organizations relevant for the activities of cleaning in sensitive areas, it is possible to define efficient and high quality guidelines and management recommendations relevant to the pollution caused by oil spills.

Furthermore, waste garbage represents threats to the maritime environment in as many ports as they can cause a potentially harmful situation. In this connection, it is possible to examine the possibilities of recycling waste garbage on board ships and the absorption of efficiency, capacity and of the methods related to the sea waste disposal. This activity can also increase the involvement of the general public in the sense that they can directly report to the port authorities on the observed larger pieces of floating debris in the sea. Finally, in the context of these activities, it is possible to make three studies: (1) Study of the Possibilities of Recycling Waste on board Ships, (2) Study of the Transportation and Disposal of Waste, and (3) Study of the Methods of How to Collect Maritime Debris with an Emphasis on Plastic.

Within these activities, several issues will be also considered. These activities will define the Master Plan in connection with the generally non-toxic pollution caused by sewage discharge. Accordingly, the outputs of this activity need to be focused on the possibility to define reserves on land or other structures that can be used for the pumping of waste from the waste water. It is also necessary to define, by the Master Plan, the discharge of ballast water, with a focus on the border areas in seaports where ballast water should be avoided as well as to inform the relevant stakeholders thereof. Finally, studies and guidelines with-

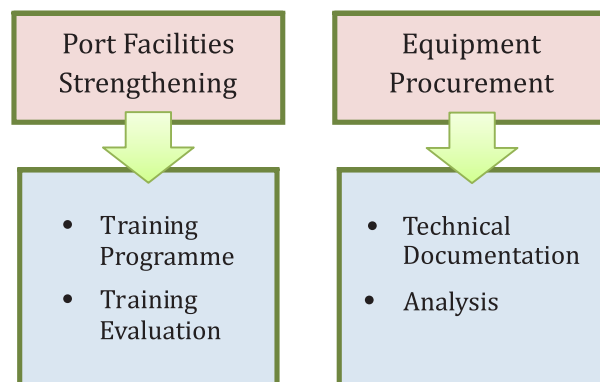
in this activity will develop methods and recommendations relevant for the prevention of unnecessary discharge of ballast water.

### 3.4 Training in emergency situations and procurement of equipment for environmental protection

The last criteria in the proposed model is of great importance because it represents a set of activities aimed at testing the implementation of the “Green Port” concept in practice. In order to obtain an adequate feedback, the implementation of the concept should be carried out in actual circumstances. Within these activities, several activities have to be suggested in order to fulfil this goal (Scheme 5).

Improving the capacity and efficiency of seaports in terms of waste management is crucial. A model within this activity needs to be focused on training programmes. Complete training programmes need to be defined on the basis of the defined “Green Port” concept. In other words, the defined Waste Management Master Plan needs to be incorporated into the concept of building or upgrading the existing port facilities focusing on possible emergency situations that may appear. Therefore, training programmes need to be in function of reducing and/or preventing potentially harmful situations. Based on the feedback obtained by the mentioned testing, it is necessary to undertake a detailed analysis of the efforts made so far in relation to port facilities and recommendations for further strengthening.

The second group of activities needs to be focused on the purchase and installation of equipment for the reception and storage of waste, related to the definitions set up in the Master Plan. Procurement of equipment includes the creation of the necessary technical documentation. It is also very important to test their current effectiveness in relation to the effectiveness after the adoption of the observed Master Plan. The analysis of the installed equipment will be determined by recommendations and definitions related to the Master Plan. Finally, a complete evaluation of the activities needs to be concluded



**Scheme 5** Training in Emergency Situations and Procurement of Equipment related to Environmental Protection.

as a recommendation in the adoption of the “Green Port” concept. Finally, based on the above-mentioned facts, it will be possible to establish networking ports that aim at developing a continuous exchange of experience and knowledge in the adoption of the green development concept and allowing the application of the results to a wide range of seaports.

It is also possible, within this model, to carry out trainings on issues related to the energy efficiency management. For example, the use of renewable energy sources, exploiting their own resources and potentials, the use of various energy forms and technologies, as well as the analysis of the supply routes and sources of energy. Renewable energy sources are highlighted as a solution for seaports because they can provide energy independently, for example solar energy with solar panels on the roofs of port buildings/warehouses.

#### 4 Conclusion

The concept of “Green Port” requires an efficient organization and leadership, coherent policies and regulations, innovations and a management system of environmental protection, energy efficiency and sustainable development. Each seaport can adopt a new, “greener” strategy and upgrade the existing system in order to define steps of the implementation of the model in order to minimize and eliminate the potential consequences of operational and illegal discharges of waste material. Therefore, most ports develop waste management plans in order to protect the port area of waste from ships and daily port operations. The proposed model for the implementation of the concept of “Green Port” development aims at achieving a low consumption of resources and the design of green logistics seaport systems as a prerequisite for achieving environmental protection, energy efficiency and sustainable development. However, the implementation is not possible without an efficient cooperation between public bodies and private companies who are the key to the successful treatment of waste in seaports and its surrounding areas.

Finally, the introduction of the concept of “Green Port” development is not only the protection of the environ-

ment but also the adoption of the concept of achieving better working conditions in the complexity of seaport operations. It provides a clear definition of responsibilities and training of internal staff, who will work in more environmental friendly area and with more environmental friendly equipment. Whatever is mentioned so far, leads to a permanent performance improvements (improving the quality of seaport services) thus positioning seaports as more competitive on the market.

#### Acknowledgment

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