

# HOW WILL GREEK PORTS BECOME GREEN PORTS?

DESPINA ANASTASOPOULOS<sup>(1,2)</sup>, DR. STAVROS KOLIOS<sup>(1)</sup>, DR. CHRYSOSTOMOS STYLIOS<sup>(1,2)</sup>

<sup>(1)</sup>Laboratory of Knowledge and Intelligent Computing (KIC-LAB), Dep. of Informatics and Communications Technology, TEI of Epirus, 47100, Artas, Greece, [desp\\_anastas@teleinfom.teiep.gr](mailto:desp_anastas@teleinfom.teiep.gr), [stavroskolios@yahoo.gr](mailto:stavroskolios@yahoo.gr), [stylis@teiep.gr](mailto:stylis@teiep.gr)

<sup>(2)</sup>Patras Science Park, Stadiou Platani 6, 26500, Platani, Patras, Greece, [stylis@psp.org.gr](mailto:stylis@psp.org.gr)

---

**Abstract.** In this study, modern, eco-friendly and cost-efficient ideas to enhance the competitiveness and to promote Green Ports are presented by taking into account the current situation of the ports, as well as the current legislation regarding the protection of the environment. This study is based on a bibliography survey, examining two Greek ports as case studies and investigating the integration and adaptation of the environmental legislation, national, international and European, in order to suggest improvements to move towards the idea of the perfect Green Port. This paper first introduces the idea of the green port. Then, the main legislation in force in Greece and Europe is briefly described aiming to answer the question if existent legislation leads to green ports or not. The existent situation in two Greek ports, the actions, and the measures that need to be made and taken in order to turn the Greek ports into Green ports are examined as case studies. The two Greek ports are the port of Igoumenitsa and the port of Patras. This paper presents the main characteristics that feature a Green port.

**Key words:** Green Ports, sustainable development, air pollution, water quality, noise pollution, weather monitoring, GIS, energy consumption

---

## 1. INTRODUCTION

Greece has the longest coastline in Europe and a strategic geographic position. There are many big operational ports, such as Piraeus, which is among the largest passenger ports in Europe, Thessaloniki, Patras and Igoumenitsa, (Amerini, 2010). Recent studies have shown that Greece has integrated in its legislation system most of the International Conventions, as well as European Directives regarding the prevention of pollution and a lot of efforts have been made in order to improve the environmental policies in the port areas. Despite all efforts, the Environmental issues are not properly addressed by the existing legislation system and its enforcement. Some of the obstacles that have been identified and need to be overcome, are the mismanagement and insufficient communication and coordination between institutions and other stakeholders responsible for implementing the legislation in the port, the complicated and fragmented legislation, the high cost of environmental law enforcement and the insufficiently effective economic incentives and sanctions

for environment protection. Even though there are great barriers to overcome, there are still smart and cost-efficient suggestions that could be adopted in order to improve their environmental impact and move towards the idea of a Green Port.

## 2. WHAT IS A GREEN PORT ?

An ecological port, also known as a green port, is a sustainable development port, which not only meets the environmental requirements, but also raises their economic interests. The core question of ecological port is to find a balance point between environmental impact and economic interests. The ports' economic social development should not exceed the carrying capacity of the corresponding natural system. The reasonable balance point is based on the correct judgment of environmental consumption and economic interests, and meets the requirement that the reversible environmental changes never happen. The main objective of the ecological port is to create good ecological environment and

high economic efficiency in the port, to ensure the overall harmonious and sustainable construction of the community-economy-environmental complex ecosystem in port, and to establish the leading position of port in modern transportation, logistics, port services, and integrated industrial system. (Shao *et al.*, 2009).

Ecological ports will be the orientation of the port development in the future, because they consist of an effective way to prevent environmental pollution and ecological damage, and to protect the aquatic resources and the natural environment of the ports. A substantial effort has been made to establish an environmental legislation and propose policies, which promote the protection of the environment especially in the port areas and the sea around that are more exposed to pollution risks and hazards due to shipping and navigation. But their adoption is not enough to characterize a port as a green port.

The concept of the Green port is to integrate environmentally friendly methods in port activities, operations and management. A green port aims to utilize efficiently its resources, to reduce the negative impact on regional environment, to raise the environment management level and improve the quality of the natural surroundings of the port area. The concept of the Green port includes the idea of protecting the environment in all its infrastructure works, in the sustainable development policies that it follows, and in all the activities and operations conducted in the area. There are plenty of measures that can be taken to establish an ecological port, such as enforcing policies that reduce air emissions, or to design properly the landscape of the port in order to include trees which absorb noise and diminish pollution. Other measures include the use of renewable energy for the port operations and activities, or to enforce sustainable practices, such as recycling and reusing these materials.

### 3. CURRENT ENVIRONMENTAL POLICIES

#### 3.1. INTERNATIONAL LEGISLATION

The International Maritime Organization (IMO), was formed by the United Nations Organization in 1948, to develop and maintain a comprehensive regulatory framework for shipping. Its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security, and the efficiency of shipping and others. The IMO conventions have been ratified by most countries, including Greece. Even though efforts have been made, there are still environmental aspects not fully covered, or there are significant conventions that haven't been ratified by all member countries. Each country is responsible to adapt the conventions into its legislation system. Moreover, many countries have adopted these conventions, but don't truly enforce it in every day practice. These conventions set the standards for many aspects, such as the MARPOL convention 1973/78 and its annexes for the pollution from ships, which set the regulations about the prevention of pollution by oil, noxious liquid

substances, garbage, and the latest, air pollution from ships. The London Convention 1972 sets the regulations for the prevention of Marine Pollution by dumping of wastes and other matter into the sea.

The existing international legislation forms an environmental framework covering the most important environmental aspects to prevent or regulate the possible pollution emerging from people's activities. The emerged question is whether these regulations are enough to establish the framework of an ecological port or not. The answer is no.

#### 3.2. EUROPEAN POLICIES

At European level, a lot of environmental policies have been established regarding, mainly, air pollution, nature and biodiversity, water and marine, soil, waste, and other factors that would reduce the environmental risks. In addition, many European directives have also been formed in order to regulate more general environmental aspects. The European directives are a must for all EU members. Each country is to adapt the European regulation and embody it in its legislation system, within a logical time period. The countries that fail to meet the set dates by the European commission are fined. There are many important European directives regarding the protection of the environment which may focus on different aspects, such as the Directive 2000/60/EC regarding the establishment of a framework for the Community action in the field of water policy.

Moreover, the European Union sets out the framework for environmental policy-making for particular periods of time and outlines actions that need to be taken to achieve them. For instance, there is the 6th Environment Action Programme of the European Community 2002-2012, refers to the development of seven Thematic Strategies in the field of soil and the marine environment (in the priority area of biodiversity), air, pesticides and urban environment (in the priority area of environment, health and quality of life) and natural resources and waste recycling (in the priority area of natural resources and waste) (Decision 1600/2002/EC). The Thematic Strategies constitute the framework for action at EU level in each of the concerned priorities. In addition, in June 2006, the European Commission published a Green Paper on the different aspects of a future Community maritime policy. The Green Paper highlights Europe's maritime identity and leadership, which is worth preserving at a time when environmental pressures are threatening the future of maritime activities. Consequently, the maritime policy aims to promote a maritime industry that is innovative, competitive, and environmentally-friendly. In addition to maritime activities, the Green Paper proposes that the approach include the issue of quality of life in coastal regions. With this aim in mind, the Green Paper considers what new tools and modes of maritime governance should be developed. Also, it starts up a reconciliation process between the development of maritime transport and environmental conservation against the background of the constraints imposed by EU regulations

under Natura 2000 and the Birds and Habitats Directives to accommodate the need to extend ports for further developing intermodal transport services [COM (2006)275 final]. The imposed European Directives partly form an environmental policy, while they set regulations and limits about different forms of pollution, such as setting the quality standards of air quality and how and when to be measured, but they do not form a concrete environmental policy for the ports.

### 3.3 NATIONAL POLICIES

Each nation draws its own environmental policy based on its own needs and obligations. The national Environmental policy is a mixture of the nation's obligations and goals. If a country is a member of the European Union it must comply, not only with the international standards, but also with the European ones. Moreover, a nation's policy and legislation is a result of the measures taken to minimize its problems and to protect its citizens from environmental hazards, as well as the plans of a nation that will lead to a sustainable environmental development.

A significant factor of the environmental policy of Greece is the legislation system, which is featured by laws that set the standard limits regarding pollution. They also include measurements taken to avoid pollution, penalties regarding exceeding the limits set by the laws, actions that must be taken in case of pollution damage, and, in general, they set the restrictive framework for all the activities that have an environmental impact.

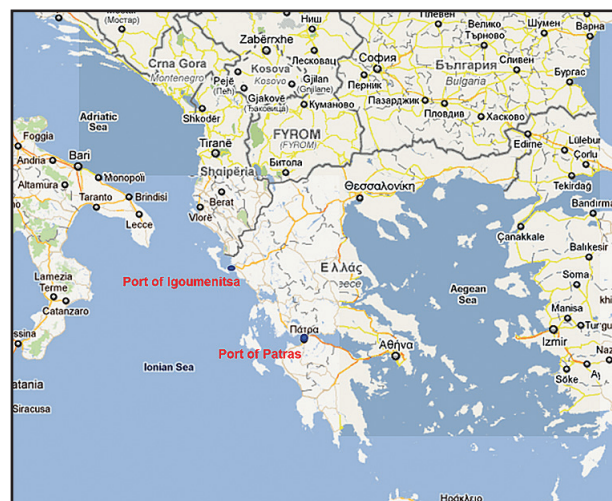
In Greece, some of the most important laws regarding the protection of the environment enforced by the ports are the Presidential Decree 55/98 regarding the protection of the sea environment (N.743/77), the Joint Ministerial Decision 50910/2727 (FEK 1909/22-12-03) regarding the "Measures and conditions for waste management, National and Regional Plan", and the Greek Law No 1739/1987 (FEK 201A/20-11-1978) "Water resource management and other apparatus". The Greek national legislation is also comprised by the transposition of the European Directives, as well as by the International conventions. Moreover, the Greek Environmental policy includes the Bilateral Agreement between Greece and Italy 1978 regarding the protection of the Ionian Sea.

The environmental policy of Greece aims to protect and improve the sea environment and the environment, in general. Thus, Greece has the National Plan of Prevention and Reducing pollution which includes different activities that contribute to the prevention of pollution. These activities involve conducting precautionary inspections and control of the inland facilities (industries, shipyards, oil refineries), as well as inspecting ships, training the involved personnel of the Ministry and the Port Authorities and preparing the inland facilities to act in case of pollution damage. Each Port Authority has planned and exercised its local Plan of Pollution Prevention and Reduction, which is designed according to their area of interest. The environmental policy also

includes the construction and functioning of the facilities for disposing ships' waste and litter in all ports in Greece; a continuous effort to modernize their equipment and the means to prevent pollution. In addition, the national plan involves the protection of specific geographic areas inhabited by rare sea species reproduce and inhabit (ex. Seal *Monachus Monachus*, sea turtle *Caretta Caretta*) or areas that are important wetlands, where animal species reproduce and take shelter. The national plan also aims to raise awareness among the citizens of environmental issues and cultivate an environmentally friendly behavior and involve citizens in the effort to protect and preserve the sea environment. Last but not least, the national plan involves the actions that must be done in case of emergency, such as the direct activation of the local or national plan of emergency and the exploitation of the means and the equipment, as well as using scientific and environmentally friendly methods to prevent and reduce the pollution of the sea and the coastal zone. (Greek Ministry of Maritime Affairs, Islands and Fisheries, 2010)

Greece has ratified most of the international IMO conventions and has adopted many of the European directives regarding the environment. In addition it has planned a National Environmental policy regarding Sea pollution but all these are not enough to establish the construction of an Ecological port. The SWOT analysis, which was conducted within the framework of ECOPORT 8 regarding the Ports of Patras and Igoumenitsa, showed that there is a need of stricter inspection, as far as the implementation and the application of the legislation is concerned (Damiani, 2010).

## 4. CURRENT ENVIRONMENTAL STATUS OF TWO GREEK PORTS



**Fig. 1** A map of Greece depicting the ports of Patras and Igoumenitsa (source: Basarsoft, Europa Technologies, Google, Tele Atlas)

This study examined two Greek ports as case studies (Figure 1). The Port of Patras (Figure 2) plays an important role in the economic life of Patras, Western Greece and Greece, in general. It is a Passengers Port which handles an important



part of the total passengers' sea traffic between Greece and other countries. It also provides services as a Commercial Port. The port of Igoumenitsa (Figure 3) falls into category A, which includes all ports of international importance. It is one of the biggest Ro-Ro ports of international transport in the country and the Eastern Mediterranean, as well. It serves mercantile action for Northern Greece, Southern Balkans (mostly Bulgaria and Turkey), as well as the Middle East countries. Two million tons of goods are transported annually through the port by trucks of international transport. It is an important junction, where Egnatia and Ionian Motorways converge.



**Fig. 2** Port of Patras (source: official website of port of Patras, [http://www.patrasport.gr/?section=1659&language=el\\_GR](http://www.patrasport.gr/?section=1659&language=el_GR))



**Fig. 3.** Port of Igoumenitsa (source: official website of port of Igoumenitsa, <http://www.olig.gr/?q=el/node/357>)

The SWOT analysis of the ports of Patras and Igoumenitsa showed that both ports plan and act according to the existing regulations regarding waste management, dredging, depositing, and the use of water bodies. In addition, the change in the structure of cargo turnover and the environmental management of the cargo in these ports and the increase of containers and Ro-Ro traffic decreases the unhealthy environmental impact in the port area, while the transport is efficiently planned. The "Plan of Waste Collection and management of ships" for both of these ports and their reception facilities of solid waste consist of skip loaders and other hauled barges and are conducted by private companies that have been authorized by the port authorities, after

successfully bidding for public procurement. Furthermore, the port authority of Patras has made the decision not to allow the transportation of hazardous merchandise because there is a lack of infrastructure to handle such cargos. Both ports have initiated the procedures to become certified as Ecological Ports from ECOPORTS-ESPO, by making the necessary improvements to implement the recommendations set in the ESPO Environmental Review of 2001 and reinforced in the new ESPO Environmental Code of Practice (2003). Regarding the infrastructures of these ports, both of them have connected most of the sewage drains in the ports to the biological treatment of wastewater of their cities for sewage treatment. The port of Igoumenitsa is using a Building Management System (BMS) to control the energy consumption and not to waste any energy. A BMS is a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems. The environmental protection measurements within the ports are under the jurisdiction of the regional authorities that are responsible to conduct the monitoring of water, air, olfactory and noise. Oceanographic measurements are conducted by the hydrographic services of the Greek Navy. There is a lack of infrastructures for the collection and partial treatment of wastewater, especially in the old parts of the ports and the collection and treatment is conducted by authorized private companies. Fortunately, both ports have developed new sections that comply with the environmental policies, but their old parts lack the required infrastructures to prevent pollution. Moreover, they don't exploit the opportunities given to recycle, reuse, and utilize waste.

In Greece, one of the biggest drawbacks to establish green ports is that the environmental legislation system is too complicated and fragmented to be enforced and it involves a lot of authorities and organizations. This results in mismanagement and insufficient communication and coordination among the responsible parties to implement the legislation in the ports leading to the insufficient administrative capacity to implement the requirements of the regulations.

In Greece, there is no integrated policy for sustainable development of the ports based on the Integrated Coastal Zone Management approach and also there is no specific legislation for the ports regarding light pollution, noise pollution and the port aquatorium. Furthermore, the ports should have modern systems that would enable them to assess the pollution risk; they should also have the right systems to monitor particular components of the sea environment that are affected by the port's activities.

## 5. TOWARDS A GREEN PORT

The overall idea of the construction of an ecological port is to approach sustainable development which is characterized by low resource consumption, little environmental impact, good growth mode, and strong scale effect. Sustainable

development ensures an economic efficiency. For a proper development of South East Europe countries, the major objectives of the Ports must be: efficient economic performance, ecological sustainability, and social equity. These objectives can be attained paying attention to: exploitation of resources, direction of investments, orientation of technology and institutional change (UNCTAD, 1993). Port sustainable development can be defined as the situation in which the port is able to meet its own needs, without endangering its own future (ESPO, 1995).

But how could the existing ports be transformed into green ports? The characterization of a green port is based on the concept of ecological environment that balances the relationships between port, transport activities human beings, and nature. All the factors related to the construction and operation of the port should raise resource utilization efficiency, reduce the negative impact on regional environment, raise the environment management level and improve environment quality in the port area. There are a lot of suggestions that can be followed in order to transform a port into a green port. Such suggestions are to design a green logistics system that aims to minimize the negative impact in the port environment; to apply cleaner production which intends to minimize waste and emissions and maximize product output, for example, by reusing waste; other suggestions are the ecological monitoring, the protection system, the ecological security management system and sustainable development of the ports based on low resource consumption.

#### 5.1 PREVENT AIR POLLUTION

The ports must reduce the pollutant emissions which are caused by their operation activities. The first step is to fully comply with the existing regulations, national, international and European, and then, to apply stricter environmental strategies within the ports. The next step is to adopt good practices that have been proven to be effective and strengthen the environmental policies in the ports.

The air quality in a port domain can be affected by the ship and vehicle exhaust emissions and is considered one of the most unknown issues in the anthropogenic air pollution (Pandolfi *et al.*, 2011), with many uncertainties and constraints in the estimating procedures of the shipping air pollutants (Miola *et al.*, 2011). More specifically, dense vehicle flows inside and nearby a port along with the use of low quality fuels of marine transport sector containing high amounts of sulfur and heavy metals are the major factors that affect air quality (Pandolfi *et al.*, 2011). Also, important factors that contribute to the atmospheric pollution can be every activity regarding the development and the repairing of infrastructure and the transportation of gaseous or liquid hazardous substances.

In addition to the existing regulations, there are some more measures that contribute to the transformation in green ports. Ports should establish an air quality improvement plan to monitor the pollution emitted within their ar-

ea by each source category (ships, cars, trucks, equipment) by installing air monitoring stations to sample and report air quality, including concentrations of key pollutants. The polluted air emitted in the port can be reduced by modernizing the equipment of cargo handling and using vehicles and equipment that consume low sulfur fuel in the ports. Modernizing the cargo equipment also enables the control of the loading ratio. Vessels are great polluters, as well as clients of the ports; therefore, ports should apply strategies that will be respected by the vessels. Ports should motivate vessels at berth by providing financial privileges (ex., providing dockage rate reductions or funding to cover the cost difference between the cleaner burning low-sulfur fuel and the heavy bunker fuel typically used) to reduce their smoke emissions by using environmental friendly fuels or by using filters or by asking the vessels to reduce their speed when entering the port, because ships emit less, when they travel slower. Other pollutant factors are the vehicles entering the port area. In order to minimize their negative impact, no vehicles should be allowed without having proper pollution control certification in the port area and regarding the highly polluting vehicles, the least required is to have special equipment, such as catalysts, which will decrease the emissions (Gupta *et al.*, 2005). Another suggestion is to provide shoreside power to cruise ships which enables the ships to plug in their vessels resulting in zero air emissions, while a ship is connected to the port (Final 2006 San Pedro Bay Ports Clean Air Action Plan Overview, 2006,). This is the most advanced technique used only in four ports all over the world. The emissions from construction operations can be reduced by wet suspension. One more suggestion is to increase the plantation of green belts all around the port areas and in the open area, because it contributes to reducing air and noise pollution.

#### 5.2 REDUCE SOIL AND SEDIMENT POLLUTION

Soil and sediments in ports have been contaminated by past industrial uses, illegal dumping, oil production and pollution entering the harbor through storm drains and rivers. The ports must manage any polluted material or source on land and in harbor sediments, so as to protect site workers, the port community and the environment, and to ensure that the pollution is not simply shifted elsewhere.

The ports should make the necessary studies to plan the removal of the identified contamination in the ports' land and sediments. This plan should include monitoring the contaminated ground water at site around the port to ensure that it will not migrate to harbor waters. Moreover, they should conduct pre-construction surveys of land, sediments, and building, so as to identify any hazardous waste and manage it appropriately.

#### 5.3. IMPROVE WATER QUALITY

Green ports plan projects to protect and improve the water quality by managing the activities that can cause water pollution.

Major sea pollutants are ship wastes and leakages, in case of accidents or bad services of ships, and infrastructure inside the periphery of the port. Also, routine activities, such as ship discharge (ballast, sewage, and spillage) contribute significantly to water pollution. The water quality can be measured via a set of parameters: transparency, PH, temperature, salinity, turbidity, suspended solid (SS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), sulfide ( $S_2$ ), nitrogen (N), mercury (Hg), lead (Pb), zinc (Zn), phosphorous (P), Cadmium (Cd), cyanide (CN), Hydrocarbons (H/C), density and types of phytoplankton and zooplankton are some of the more usual parameters that are measured to study the quality of the water (Saengsupavanich *et al.*, 2009). Every port should develop a Storm Water Pollution Prevention Program to manage storm water, including industrial, construction, municipal and development activities. Such programs could include regular cleaning of the paved roads that will result in the sewage drain.

Moreover, all the contaminated water from the port surface must result in sewage drains which should be connected to the city's sewage treatment plant. The existing regulations regarding the ship discharges also contribute to minimize the pollution in the port aquatorium. The enforcement of the regulations is more than necessary and stricter inspections are obligatory.

A fine method to improve the water quality is by installing sensors that will inform the authorities in real time about the pollution risk and enable them to take the right measures without wasting any time.

#### 5.4 IMPROVE WILDLIFE – MARINE LIFE

A green port needs to conduct periodical analytical environmental studies about the surrounding natural (marine and land) ecosystem, taking account of the necessary initiatives to balance the port activities and the conservation of flora and fauna of the ecosystem. This would require environmental studies, not only to identify the species in the area, but also the possible damage caused by the port activities. The ports should monitor wildlife by tracking several indicators of habitat quality, including the abundance of birds and the number of fish species found in the harbor during periodic biological surveys. If the ecosystem is damaged, the ports must plan restoration programs that will contribute to the rehabilitation of the area and protect the ecosystem.

The phenomenon of the disturbance of wildlife and marine life is reflected by the quality of the port aquatorium, the air quality, as well as the noise and light pollution. Any measure enforced to eliminate these problems interacts, in a positive way, to strengthen the balance of the ecosystem in and around the ports.

#### 5.5 REDUCE ENERGY CONSUMPTION

There is significant energy consumption from the light at terminals, offices (computers, and other devices that, even in the "stand by" mode, consume energy) and the heating/

cooling devices and lighting used in the whole port's infrastructure

A Green Port should enforce energy efficiency policies in order to reduce the energy consumption. New strategies should be planned and implemented, based on new forms of energy and, mostly, on the renewable ones (especially solar and wind). These strategies must focus on the installation, maintenance, usage and storage of renewable and eco-friendly forms of energy.

Moreover, ports should conduct energy consumption studies, in the whole infrastructure areas of the ports, as well as in the locations outside their perimeters, so as to assess the caused damage and to enable them to incorporate energy efficiency studies to eliminate unnecessary energy consumption and change fixtures to become more cost-efficient. These studies will give them an overall estimation of the situation, so as to issue efficient policies to restrict ship/rail/truck/infrastructure energy consumption and to decrease the illuminating areas outside the port properties perimeters, when they are not moving or, even, alter operation schedules to avoid light pollution during night hours (Corson *et al.*, 2008).

#### 5.6 REDUCE NOISE POLLUTION

Another environmental factor that disturbs the ecological balance is the noise produced within the port areas, due to their operation, the vehicle and ship traffic. Noise pollution is pointed out as the current top environmental priority by the European port sector. The European Noise Directive is considered to be one of the main triggering factors for the high priority on noise within the ports environmental agenda. (ESPO/EcoPorts Environmental Review, 2009). Green ports should draw their own policy or strategy by conducting noise abatement studies, issue policies regulating the activation of sirens, horns, vehicle warning "beepers", and other sources of noise from port. Ports should determine effective source mitigation measures by carrying out technical sound measurements at a defined distance to the equipment, by an acoustic expert, in order to measure the states of the main operations, such as lifting, lowering, driving, and idling and to calculate, both the sound level of the equipment, and the operation state with the main influence. Defining the most essential factors makes it easier to plan the appropriate actions that must be carried on to reduce noise pollution. Some suggested actions for the terminals are: covering of sound intensive components with insulation reducing structure-borne sound radiation, use absorbing building materials, reducing the speed of putting down a container and distance from surface of opening a bulk grab, low noise driving (ECO-driving), follow up service of noise reduction, automatic positioning of the spreader, avoid night-open terminal (allow seaside activities, tyre pressures, but no land-operations with trailers through gates), put noise source into a building or barriers around noise source, GPS of containers, so as to reduce sound peaks, silent exhaust pipes, electricity, instead of diesel or diesel-electric moving equipment, planting trees as a barrier



(may act as both physical and perceived barrier), use water cooling systems, instead of air cooling, use softer ground where activities allow (e.g. quiet asphalt). Port authorities could motivate ships to use silent exhaust pipes and ventilators. Green ports should not allow loud speakers at berth and they should supply ship-shore energy during berthing in order to reduce noise. (Breemen, 2008).

#### 5.7 IMPROVE WEATHER MONITORING

Another important issue that is not taken into account are the extreme weather conditions. In general, the weather conditions (among others, temperature, humidity, wind direction and intensity) play a crucial role in the port activities, because they can affect the labour productivity, the visibility at the terminals and in mooring procedures, the instantaneous air pollution in the port area (Contini *et al.*, 2011), the possibility of accidents during the loading/unloading, transportation and storage of cargoes, or sensible products. As a final result, the weather conditions can cause financial losses of the port's incomings because of accidents, delays and productivity decreasing. This factor can play a more important role in the case of ports without bulwarks and is of crucial importance for them to be continually informed about the weather conditions (especially, the extreme ones), in order to protect staff, infrastructure and cargoes and, overall, the whole transportation chain from accidents and delays.

It is important for modern green ports to establish weather station networks for analytic and continuous monitoring and models for weather forecasting. This will contribute, not only to the increase of reliability and the quality of the provided services, the staff and infrastructure safety, the overall agility of port activities, but also to the improvement of the infrastructure, in order to decrease or prevent impacts from extreme weather phenomena and accidents that, in the past, have led to many serious environmental disasters.

#### 5.8 MODERN ENVIRONMENTAL PERSPECTIVES FOR GREEN PORTS

Geographic Information Systems (GIS) are well-known, widely spread, and used for monitoring of spatiotemporal characteristics, storage and analysis of data in many scientific fields. These systems are ideal for environmental monitoring, because they allow the implementation and integration of many different data sources and their automatic spatial analysis and modeling.

More specifically, GIS applications are continuously developing for monitoring, analysis and modeling spatiotemporal changes of many parameters and phenomena, such as air pollution (Song and Lee, 2010; Tolga *et al.*, 2010), coastlines (Mujabar and Chadrasekar, 2011) land use (Xu *et al.*, 2011) and many others, integrating different data and techniques with reliable results. In recent years, GIS applications for monitoring causes and results of environmental changes, use remotely sensed data from polar-orbiting satellite sensors, improving the analysis and giving new perspectives

to the environmental monitoring and modeling (Vemu and Pinnamaneni, 2011, Janet *et al.*, 2010; Feldman *et al.*, 2010). Considering the above, GIS applications can be, not only a valuable tool for a continuous and accurate monitoring of environmental impacts of port activities, but a decision making system, planning strategies for sustainable port development.

#### 5.9 ACHIEVE SUSTAINABILITY

In order to achieve sustainability, sustainable practices should be implemented during the design and construction, the operations and, even, throughout the administrative management. The sustainable practices are aiming to reduce pollution, by all means and in all fields. One applicable sustainable practice is recycling. Each port can recycle everything, from plastic (bottles) and paper (newspapers, magazines) to tyres and computers. The ports must apply recycling policies and they must also reuse these materials. Other ways to achieve sustainability are to improve the air quality, to make energy and fuel efficiency improvements, such as using alternative sources of energy in the port, such as solar energy or hydroelectric power, or by replacing the port vehicles with alternative fuel vehicles. In addition, the ports should apply energy efficiency plans, such as the BMS (Building Management System), which controls the energy consumption in their building.

### 6. CONCLUSIONS

Ports play an important role in the global transport of goods and people, and they involve many factors, such as ship companies, truck companies, logistics companies, local authorities, citizens, etc. Also, they have a direct impact on the natural environment because of their heavy traffic. The existing regulations set up an environmental framework regarding the limits, precaution measures, emergency plans. However, all these are not enough to establish an Ecological port. Adopting and applying the idea of an ecological port would be a great achievement, while there will be a direct influence on all the involved parties to create an overall Green behaviour and respect the environment. This paper presents suggestions of how to transform a port into a Green port. Some of these suggestions require advanced technology and funding, while others are cost-efficient and do not need special skills to apply them. These suggestions might be a small contribution to a big effort: "to save our planet".

### 7. ACKNOWLEDGEMENTS

This research was conducted within the framework of the Environmental Management of Transborder Corridor Ports, ECOPORT 8 project, which was funded by South East Europe Transnational Cooperation Programme under the Priority Axis 2: Protection and Improvement of the environment, Area of Intervention 2.2: Improve prevention of environmental risks.

## REFERENCES

- AMERINI G., 2010. European Port Activity in 2009 hit by the general economic crisis, *Transport statistics in Focus Eurostat*, 65/2010, 9-10
- COMMISSION OF THE EUROPEAN COMMUNITIES, 2006. Green Paper - Towards a future Maritime Policy for the Union: a European vision for the oceans and seas, com (2006) 275 final volume II ANNEX, Brussels
- CONTINI D., GAMBARO A., BELOSI F., DE PIERI S., CAIRNS W.R.L., DONATEO A., ZANOTTO E., CITRON M., 2011. The direct influence of ship traffic on atmospheric PM<sub>2.5</sub>, PM<sub>10</sub> and PAH, *Venice. Journal of environmental management*, 92, 2119-2129.
- DAMIANI L., 2010. Technical Report Deliverable WP 4.3 SWOT Analysis of Standards and Practices adopted in the Environmental field, Environmental Management of Transborder Corridor Ports 8 (ECOPORT 8) project- Code SEE/A/218/2.2/X, chapter 5, 12-16
- DECISION No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme *OJ L 242*, 10.9.2002, p. 1–15
- DIRECTIVE 2000/60/EC of the European Parliament and of the Council “establishing a framework for the Community action in the field of water policy”, 22 December 2000 in the *Official Journal (OJ L 327)*
- EUROPEAN SEA PORTS ORGANIZATION, 1995. Environmental Code of Practice, Brussels: European Sea Ports Organization Secretariat
- FELDMAN M.S., HOWARD T., McDONALD-BULLER E., MULLINS G., ALLEN D.T., HASEL A., WISTHALER A., 2010. Applications of satellite remote sensing data for estimating biogenic emissions in southeastern Texas. *Atmospheric Environment*, **44**, 917-929.
- GREEK JOINT MINISTERIAL DECISION 50910/2727 (FEK 1909/22-12-03), 2003. Measures and conditions for waste management, National and Regional Plan, Athens Gr.: Hellenic National Printing House
- GREEK LAW No 1739/1987 (FEK 201A/20-11-1978), 1978. Water resource management and other apparatus, Athens Gr.: Hellenic National Printing House
- GREEK PRESIDENTIAL DECREE 55/98 (FEK 58A/20-3-83), 1983. Protection of the sea environment (N.743/77), Athens Gr.: Hellenic National Printing House
- GUPTA A.K., GUPTA S.K., RASHMI S.PATIL, 2005. *Environmental management plan for port and harbor projects, Clean Technologies and Environmental policy*, volume **7**, Number 2, DOI: 10.1007/s10098-004-0266-7, 133-141
- INTERNATIONAL MARITIME ORGANIZATION, 2006. *Marpol Consolidated Edition 2006*, ISBN number: 92-801-4216-X
- INTERNATIONAL MARITIME ORGANIZATION (IMO), 2003. *London Convention 1972 and 1996 Protocol*, ISBN number: 92-801-4155-4
- CORSON L, PH.D., FISHER S, 2008. Manual of Best Management Practices for Port Operations And Model Environmental Management System, *Great Lakes Maritime Research Institute*, 45-48
- MIOLA A, CIUFFO B., 2011. Estimating air emissions from ships: Meta-analysis of modeling approaches and available data sources. *Atmospheric environment*, **45**, 2242-2251.
- MUJABAR S., CHADRASEKAR 2011. A shoreline change analysis along the coast between Kanyakumari and Tuticorin, India using Digital shoreline analysis system. *Geo-spatial information science*, **14**, **4**, 282-293.
- TON VAN BREEMEN, 2008. Good Practice Guide on Port Area Noise Mapping and management, *Noise Management in European Ports (NoMEPorts) project*, LIFE05 ENV/NL/000018, 44-50.
- PANDOLFI M., GONZALEZ-CASTANEDO Y., ALASTUEY A., DE LA ROSA J., MANTILLA E., SANCHEZ DE LA CAMPA A., QUEROL X., PEY J., AMATO F., MORENO T., 2011. Source apportionment of PM<sub>10</sub> and PM<sub>2.5</sub> at multiple sites in the strait of Gibraltar by PMF: impact of shipping emissions. *Environmental science and pollution research*, **18**, 260-269.
- PORT OF LOS ANGELES, PORT OF LONG BEACH. 2006. Final 2006 San Pedro Bay Ports Clean Air Action Plan Overview, Available from: <http://www.polb.com/environment/air/caap.asp>
- SAENGSUPAVANICH C., COOWANITWONG N., GALLARDO W.G., LERTSUCHATAVANICH C., 2009. Environmental performance of an industrial port and estate: ISO 14001, port state control-derived indicators. *Journal of Cleaner Production*, **17**, 154 - 161.
- SHAO CHAO-FENG, JU MEI-TING, YU JING-LEI, HU CUI-JUAN, CHU CHUN-LI, 2009. The strategies and proposals for ecological port construction in China in *Journal US-China Public Administration*, Volume **6**, No 7(Serial No 50).
- SONG J., LEE H., 2010. Comparison analysis of the marine air emissions using Tier 1 and Tier 3 methods in a port area. *Proceedings of the Air and Waste Management Association's Annual Conference and Exhibition*, **AWMA 7**, 5290-5306
- TOLGA E., NIZAMETTIN M., MELIK K., SEDEF S., TUBA E., SEDA O., 2010. Development of a GIS-based decision support system for urban air quality management in the city of Istanbul. *Atmospheric Environment*, **44**, 41-454.
- UNCTAD, 1993. Sustainable Development for Ports, *Report UNCTAD (SDD/Port) 1*, **27/8**, Geneva :UNCTAD.
- VEMU S., PINNAMANENI U.B., 2011. Estimation of spatial patterns of soil erosion using remote sensing and GIS: a case study of Indravati catchment. *Natural Hazards*, **59**, 1299-1315.
- VERHOEVEN P., JOURNÉE H., 2009. ESPO/EcoPorts Environmental review 2009 - European Sea Ports Organisation's Review of Environmental Benchmark Performance in collaboration with the EcoPorts Foundation (EPF), Brussels: European Sea Ports Organization Secretariat
- XU Y., LUO D., PENG J., 2011. Land use change and soil erosion in the Maotiao River watershed of Guizhou Province. *Journal of Geographical sciences*, **21**, **6**, 1138-1152.