30MILES - Small port every 30 miles apart: development of services for lively water tourism in the Eastern Gulf of Finland

Literature review: Sustainable ports

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1. Introduction

Seaports play a vital economic role both globally and regionally: ports provide direct and indirect employment, attract tourists and act as important parts of global maritime transport industry (Hiranandani, 2014; Kuznetsov, 2014). However, port activities form a major source of pollution in coastal waters: shipping, dredging, ballast water, and storage and transport of hazardous material are considered as significant threats to the often sensitive coastal habitats and ecosystems, environmental impacts including i.e. air (Bailey and Solomon, 2004), soil (Gupta et al., 2015) and water pollution (Grifoll et al., 2011). The environmental impacts depend on several factors including port size, type of activity, traffic volume and the local geography and hydrology. Therefore, developing a framework for sustainable port activities and environmental protecting is challenging.

The 30MILES project aims at improving the overall service level and safety of 11 small ports in Finland and Estonia. At the moment, the small ports are acting alone, and developing a competitive network of small ports is seen as a precondition for lively and sustainable water tourism in the Eastern Gulf of Finland and in increasing the overall attractiveness of the region. Within the 30MILES project, Fisheries and Environmental Management group (University of Helsinki) will utilize their modelling knowledge to improve the sustainable development of marinas and small ports. A Bayesian decision model will be developed for making sustainable development plans[1]. This literature review examines the existing research on sustainable ports and outlines the need for further research within the 30MILES project.

Research on sustainable ports has mainly focused on the different environmental impacts of the activities related the ports and port construction (Wooldridge, 1999), on Environmental Management Systems (EMS) of ports (Darbra et al., 2004) and on developing new indicators for managing environmental impacts of ports (Peris et al., 2005; Puig et al., 2014). In addition, strategic issues have been researched, such as studies on sustainable supply chains (Asgari et al, 2015; Denktas-Sagar and Karatas-Cetin, 2012), and on sustainable port development (Yap and Lam 2013) and green port strategies (Lam and van der Voorde, 2012). Also, the role of innovations in improving environmental sustainability has been studied (Acciaro et al., 2014). Some studies have adopted a more comprehensive approach to sustainability calling for and integrated and holistic approach to

[1] Bayesian statistics use probability as a measure of uncertainty and Bayesian modelling has been increasingly used for modelling uncertain and complex domains such as ecosystems and environmental management (Uusitalo et al., 2007).

sustainable port policies and practices based on stakeholder participation (Hiranandani, 2014; Kuznetsov et al., 2015; Le et al., 2014).

While most of the research has discussed sustainability in terms of larger marine ports, research on smaller ports is limited: some studies, however, exist on inland ports (Dooms and Macharis, 2003) and on smaller recreational ports (Dinwoodie et al., 2012; Lapinskiene et al., 2014; Kuznetsov, 2014; Tselentis, 2008). Where Dinwoodie et al. (2012) focuses on the business processes in environmental management of small ports, Kuznetsov (2014) develops a port sustainability management system (PSMS) based on eleven indicators to empower the harbor masters (HMs) to proactively assess the state of sustainability of small ports. Such an approach is useful also within the 30MILES project, and with the use of Bayesian modelling, a new method for assessing port sustainability will be developed.

Here, some of the different approaches to sustainable ports are first briefly presented, including the different Environmental Management Systems (EMS) applied to seaports, the strategic approaches adding to the ports financial performance, and finally the existing research on small, recreational ports. The different definitions of sustainability related to ports are then summarized (See appendix 1 for the summary table). Finally, based on the literature review, an outline for further research within the 30MILES project will be developed. For this literature review, key articles were selected by first skimming through the newest articles found with search words “sustainable ports”, “recreational port” and “small port sustainability”, and then working backwards and 1) selecting some of the often cited, older, articles 2) as well as articles with different approaches to sustainability. The research portals used were SCOPUS, Web of Science, and Google Scholar.

2. Different Approaches

2.1. Environmental Management Systems (EMS) for seaports

Large seaports form a major source of pollution in coastal waters. The environmental impacts are various and have been widely discussed in the literature, i.e. studies on dredging (Bateman, 1996; Bolam et al., 2006), ballast water (Gray et al., 2007; Gollasch, 1997), water pollution (Grifoll et al., 2011) and air pollution and emissions (Bailey and Solomon, 2004; Liao et al., 2010). The European Sea Ports Organization (ESPO) has listed the top 10 environmental priorities in European ports sector 2013 (see table 1).

1. **Air quality**
2. **Garbage/ Port waste**
3. **Energy consumption**
4. **Noise**
5. **Ship waste**
6. **Relationship with local community**
7. **Dredging: operations**
8. **Dust**
9. **Port Development/ Land**
10. **Water quality**

Table 1. Top 10 environmental priorities of the European ports sector in 2013 (ESPO, 2013).

The environmental impacts, however, depend on the characteristics of each port, such as the size, operations, industry base, traffic volume, and the local geography and hydrography (Wooldridge et al., 1999). In addition, the differing social and regulatory context have an effect on the environmental impact of the ports (Puente-Rodrigues et al., 2016). In Finland, in the case of smaller, recreational ports, the main environmental impacts include garbage/ port waste, sewage water, small oil leaks, and toxic anti-fouling paints (Pidä Saaristo Siistinä, 2016). In addition, industrial waste and agricultural runoff often reduce water and sediment quality in small ports (Tselentis, 2008; Lapinskiene et al., 2011).

The range and diversity of port locations presents a challenge in developing "a unified response to the demands of sustainable development and environmental protection "of ports (Wooldridge et al., 1999). Since the late 90's, Environmental Management Systems (EMS) tools for larger, commercial marine ports have been developed and discussed widely (i.e. Darbra et al., 2004; Dinwoodie, 2012; Peris et al., 2005; Puente-Rodriguez, 2016; Wooldridge et al., 1999). Even though the indicators described here are targeted at large seaports, there is a need for developing such indicators also for recreational ports, and as explained later, one of the aims of the 30MILES project is to contribute to developing such indicators.

Understanding the range of environmental issues is the key to managing the environmental impacts of ports (Wooldridge et al., 1999). In their paper, Wooldridge et al. (ibid) provide an overview of the different physical and chemical parameters to assess environmental quality, and argue also that mapping the marine habitats and studying the biological indicators such as the occurrence of

particular species, species richness and diversity indices is needed to support environmental decision making.

Different initiatives have been developed for protecting the environment in the port sector. In terms of smaller recreational ports, the European Foundation for Environmental Education developed the European Blue Flag project in 1987 to implement environmental protection of beaches and marinas. However, most initiatives have focused on larger marine ports: examples include the ECO INFORMATION project started in 1997 by the Amsterdam Port Authority and the Rotterdam port the GREEN AWARD system that was initiated the same year (Peris et al., 2005). In addition, the European Sea Ports Organization (ESPO) was founded in 1993 and represents the sea ports in all the maritime states of the European Union. In the ESPO Code of Practice 1994, the use of Environmental Performance Indicators (EPIs) and monitoring of environmental impacts was encouraged. Through the EcoPorts network, initiated in 1994, ESPO has developed port- specific tools for facilitating the articulation of ports' environmental management system (EMS). EMS is a tool for marine port authorities for managing environmental performance of organization through design, pollution control, waste minimization, training, reporting to top management and the setting of specific goals (Le et al, 2014).

EMS port tools include the Self-Diagnosis Method (SDM), the Port environmental review system (PERS), the Eco-management scheme and audit scheme (EMAS) and the ISO 14001. While EMAS requirements and the ISO 14001 require explicit commitment to continuous improvement of environmental performance through the use of performance indicators, SDM and PERS have been developed to assist ports to acquire the more full-fledged management system certifications (Darbra et al., 2004). The common tools to assist environmental management are presented in table 2. All of the tools are voluntary for the ports to implement.

Initiative	Aims to:	Implementation
Self-diagnosis method (SDM)	Identify environmental risks and establish priorities for action and compliance	Port manager completes a checklist. EcoPorts guidance on benchmarking performance; analysis of strengths, weaknesses, opportunities and threats; strategic advice
Port environmental review system (PERS)	Assist ports to implement an environmental management system (EMS) through developing components within it to raise its effectiveness	Ecoports offer an independent review consisting of guidelines and example documents
Strategic overview of environmental aspects (SOSEA)	Identify 'significant' environmental aspects arising from operations; guide ports in gathering information to manage liabilities and responsibilities; enhance long-term strategic development and increase environmental awareness	Port indicates to Ecoports whether each of 12 environmental 'aspects' applies to activities which include bunkering, but not anchoring. An aspect is 'significant' if the number of ticks against it or a breach of legislation are 'significant'. For each significant aspect further questions on management and actions taken
ISO 14001	Promote continual improvements by encouraging ports to adopt and implement EMS; assist systematic development of a formalised management process, and evaluate effectiveness of activities, operations, products and services	Continuous monitoring improves understanding and assists risk management, supported by appropriate data collection techniques and record keeping
Eco-management scheme and audit scheme (EMAS)	Promote ongoing improvements	Preparation of an environmental review and statement. See regulation EC1221/2009
Associated British Ports	Identify environmental issues and associated risks; achieve scale economies	Multi-site applications of standardised procedures

Table 2. Some tools to assist environmental management of in ports (Dinwoodie et al., 2012)

The Self Diagnosis Method (SDM) is fully presented in the paper by Darbra et al. (2004). SDM provides a checklist against which port managers can self-assess the performance of the port in relation of both the European port sector and international standards: the tool provides a time and cost-efficient methodology for identifying environmental risk and establishing priorities for action and compliance. The tool is mutually consistent and based on ISO 14001 and EMAS requirements and can help the ports in applying for higher level methodology (Darbra et al., 2004).

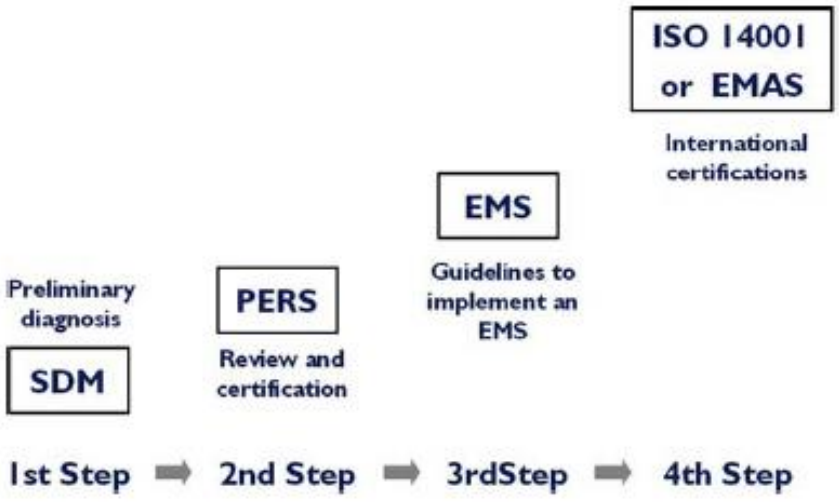

Figure 1. The relationship between ECOPORTS tools and the international standards (Darbra et al., 2004)

Research also exist on different environmental indicators in terms of sustainable port development. Based on a case study of the port of Valencia (the second largest port in Spain), Peris et al. (2005) consider the use and development of environmental indicators for sustainable management of port activities. Twenty-one port activities were considered and identified, 63 potential environmental impacts were found, and a total of 17 pressure/state indicators were chosen for port environmental policy. Indicators were defined as:

"instruments which evaluate the positive or negative state of the environment and the consequences of applied measures. An environmental indicator is a parameter or value resulting from a group of parameters which provides information regarding a phenomenon with a broader significance than that directly associated with the configuration of the parameter" (OECD, 1993).

In addition, Puig et al. (2014) have identified and selected key Environmental Performance Indicators (EPIs) for sustainable port development. According to Puig et al. (2014), even though ports are increasingly using environmental indicators to monitor trends in environmental performance, no common approach to the use of indicators exists. In the paper, inventory of the existing EPIs was identified including monitoring the performance of operational (e.g. dust, noise, dredging, and waste), managerial (e.g. certifications, compliance and complaints) and environmental condition (e.g. air, water, sediment and ecosystems). Based on assessment and evaluation carried by port stakeholders, a final set 12 of indicators suitable for implementation at EU level were obtained. (The environmental indicators were excluded from the final set, as suggested by the stakeholders, since the environmental impacts differ from one port to another). The adoption of the indicators can bring benefits to port authorities in terms of monitoring the environmental performance progress made, provide a picture of trends over time, and measure the extent of which goals are being achieved (Puig et al., 2014). The studies including the key impacts of port activities and indicators/ methods developed are summarized in the table below (See table 3).

Darbra et al., 2004	Peris et al., 2005	Puig et al., 2014
Environmental impacts Garbage/port waste, dredging disposal, dredging, dust, port development, noise, hazardous cargo, air quality, water quality, ship discharge (bilge)	**Environmental impacts** Air pollution, noise pollution, odor pollution, water pollution, soil pollution, waste creation, resource consumption, Other	**Environmental impacts** ---
Self Diagnosis Method (including two parts) 1. Port profile: Legal status and port operators, port location and port area, port business, main commercial activities and cargo handling, main cargo 2. Environmental management and procedures: Environmental policy, management organization and personnel, environmental training, communication, operational management, emergency planning, monitoring and records, review and audit Four types of feedback on results: baseline results, European benchmark comparison results, GAP and SWOT analysis	**17 Indicators** Air quality, atmospheric contaminant emissions, gas emissions with greenhouse effect, noise pollution, inner port water quality, amount and description of accidental spills in inner port waters, quality of spilled waste water, high risk areas for soil pollution, urban and dangerous waste creation, creation of sludge from dredging, efficient water consumption, efficient electric energy consumption, alteration of sea floor, soil occupation efficiency, social image of the port, number of incidents with environmental repercussions	**12 Key Environmental Indicators** *Management indicators:* Environmental Management system, Environmental monitoring program, Inventory of significant environmental aspects, Environmental policy, ESPO Code of Practise, Inventory of Environmental legislation, Objectives and targets, Environmental training, Environmental report *Operational indicators:* Carbon footprint, Waste management, Water consumption

Table 3. Summary of key studies on environmental management systems (EMS) and environmental indicators for sustainable ports.

2.2 Strategic planning and sustainable chain management

Ports operate in highly complex and competitive environment and port authorities have become increasingly aware of the need for strategic planning of their operations (Dooms and Macharis, 2003). Similarly, the focus of research on sustainable ports has shifted towards strategic planning of port operations and the relationship between sustainability and the economic performance, recent studies including i.e. research on stakeholder management of ports (Dooms and Macharis, 2003), sustainable supply chains (Asgari et al., 2015; Denktas-Sakar and Karatas-Cetin, 2012) and sustainable port development (Yap and Lam, 2013) and green ports (Van de Voorde, 2012).

While Asgari et al. (2015) investigate sustainable supply chains by examining the sustainability performance of major UK ports from the economic and environmental perspective, and Dinwoodie et al. (2012) argue that business operations should be incorporated to the sustainability agendas of small ports, Denktas-Sakar and Karatas-Cetin (2012) argue that in developing sustainable supply chains, also the social aspect is important: ports should adopt strategic tools that enhance effective stakeholder relations management and port sustainability. This can be considered important also within the 30MILES project as explained later. Stakeholder management theory has been applied to the port sector only recently, however, as ports face constant pressure from a variety of stakeholders (including i.e. urban residents, leisure industry, and environmental organizations), there is a need for collaborative stakeholder approach and management that can help both in creating policy objectives and measures aimed at sustainable urban development as well as providing the ports with strategic business-orientated benefits (Dooms and Macharis, 2003).

Lam and Van de Voorde (2012) provide a framework for sustainable port strategies with the aim of integrating economic and social aspects into environmental concerns, referring to the UN's triple bottom (TBL) line. The authors develop a sustainable port framework including stakeholder involvement (stakeholders were divided into market players, public policy makers, internal stakeholders and community), green market development and cost effective green policy (See figure 2). Lam and Van de Voorde argue that green ports will lead to positive outcome on port's customer retention and economic performance and that the model demonstrates that environmental protection go hand in hand with commercial tactics including marketing and costing "so that triple bottom line is met" (2012).

Figure 2. Green and sustainable port framework (Lam and Van de Voorde, 2012)

Furthermore, Yap and Lam (2013) in their study on four container ports (Shanghai, Singapore, Hong Kong and Shenzhen) and their likely growth patterns, sustainability issues in port development and the related policy implications, call for an integrated approach that includes cross-sectoral management, strategic environmental assessment, systematic scientific research and public involvement to tackle with the environmental impacts of the projected increase of container port industry.

2.3 Recreational ports

Similarly to larger sea ports, recreational ports often serve an important economic role locally. In the case of small ports, the importance of compliance to different environmental regulations is highlighted in helping to preserve local employment, to attract tourists, as well as to maintain and grow local economy (Kuznetsov et al., 2015). Most of the research on sustainable ports and environmental management of ports, however, focus on larger marine ports and little research exists on small recreational ports and their environmental assessment (Lapienskiene et al., 2011). In addition, systematic sustainability management in small ports have remained rare (Kuznetsov et al., 2015).

Monitoring of basic environmental parameters is essential for effective policymaking also for recreational ports (Tselentis, 2008; Lapinskiene et al., 2011). While Tselentis (2008) discusses the importance of monitoring basic environmental parameters and the implementation of already existing types of EMS (ISO 14001, EMAS and PERS) in Greek recreational ports, Lapinskiene et al. (2011) developed a new method for evaluating the sustainable development of recreational ports based on systematic analysis of the case study example, Sventoji small port (Lithuania). The analysis

included identifying the existing port operations and processes, the technogenic port processes, and the evaluation of the significant natural environment and technogenic environment aspects. In addition, the factors with highest environmental impact were identified (in the case of Sventoji, waste, water pollution and air pollution were the most significant impacts) and the possible measures to reduce the environmental impact were evaluated (such as usage of recycling and applying alternative technologies for water heating, waste management and air pollution control). (See figure 3. for the model).

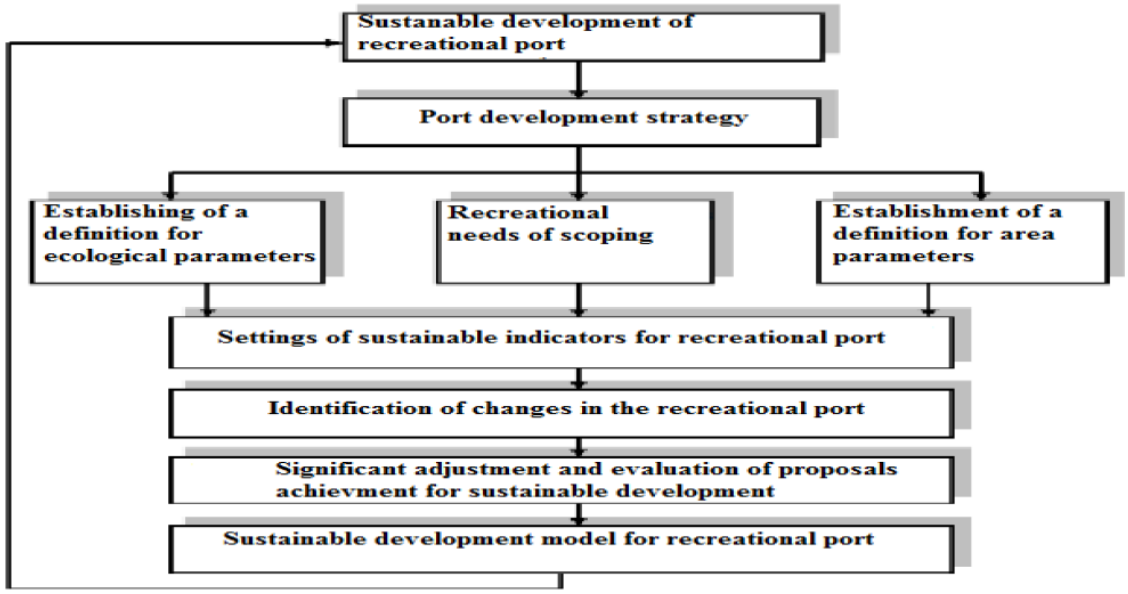

Figure 3. Model of sustainable development of a small port (Lapinskiene et al., 2011).

In addition, incorporating business strategies with environmental management can encourage the adoption of sustainability agendas of small ports (Dinwoodie et al., 2012). Furthemore, Kuznetsov et al. (2015) developed a comprehensive approach to sustainable management of small ports. The costs related to ISO 14001 certification, assessment and auditing as well as the EcoPort tools are often too high for smaller ports (Dinwoodie et al., 2012; Kuznetsov et al., 2015). The smaller ports therefore need an affordable process for managing their environmental impacts and sustainability and new ways to adopt proactive approach to sustainability to help to safeguard their current business, to protect local employment and to support sustainability principles (Dinwoodie et al., 2012; Kuznetsov et al., 2015).

The developed framework, the Port Sustainability Management Systems (PSMS), seeks to support harbor masters (HMs) and environmental managers of ports to proactively assess the sustainability

of ports by increasing the HMs knowledge around port sustainability and by helping to identify the strengths and weakness in order to apply relevant knowledge and to assess the impact of that knowledge (Kuznetsov et al., 2015). The framework, that is based on in-depth interviews and of over two years collaboration with HMs in the Cornwall and Devon area, UK, combines eleven themes of harbor operations which together constitute to overall harbor sustainability (See figure 4.) In addition, each of the 11 indicators of PSMS includes a set of criteria ranging from 1 to 5: these offer examples of how to achieve a certain category for particular sustainability criteria. (See figure 5.)

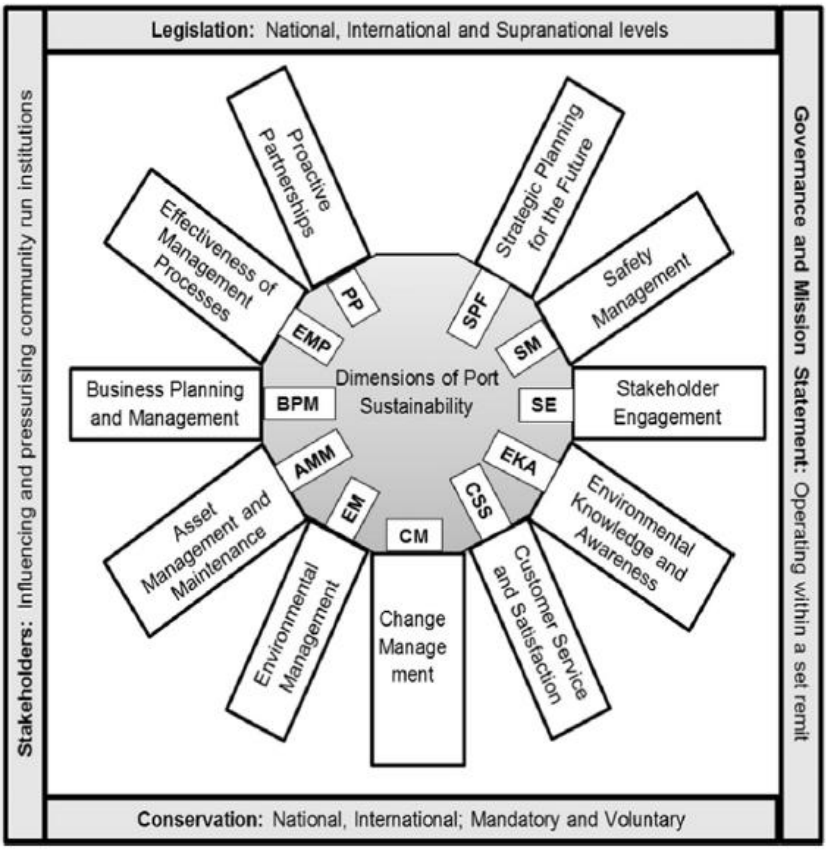

Figure 4 Theoretical framework for Port Sustainability Management System (PSMS) (Kuznetsov et al., 2015).

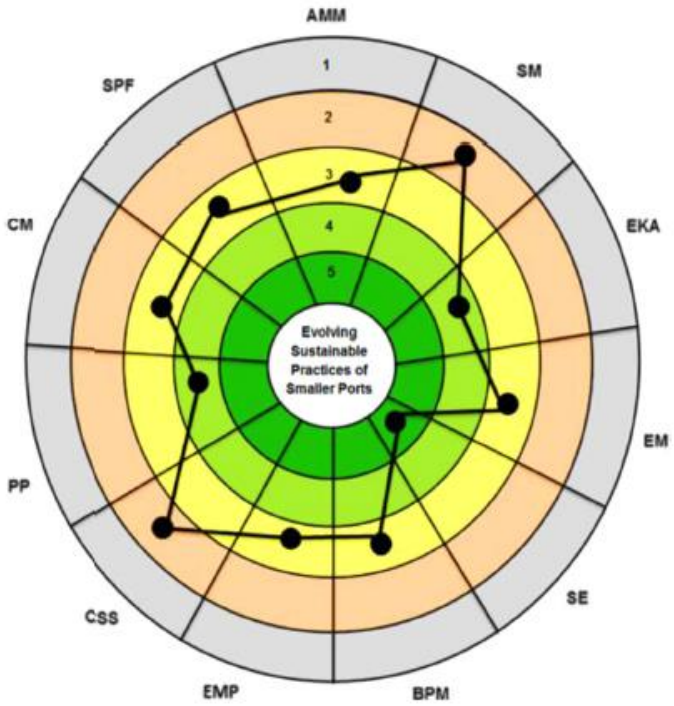

Figure 5. The Port Sustainability Management System (PSMS) (Kuznetsov et al., 2015).

3. Sustainability definitions

Research on port sustainability has largely focused on identifying the different environmental impacts of port activities and port construction and on the different environmental management systems (EMS) and use of environmental indicators (Wooldridge et al., 1999; Darbra et al., 2004; Peris et al., 2005). The focus has, however, started to shift towards incorporating the economic and social aspects with the environmental one. Much of the recent literature on sustainable ports (i.e. Asgari et al., 2015; Hiranandani, 2014; Lam and Van de Voorde, 2012) rely on the Brundlandt Commission definition of sustainable development: "meeting the needs of the present without compromising the ability of the future generations to meet their own needs" (1987). In addition, the triple bottom line (TBL) is often referred to: the TBL was first developed by Elkington (1997) and then adopted by the UN (see figure 6). As such, sustainability refers to the equilibrium between economic, environmental and social aspects.

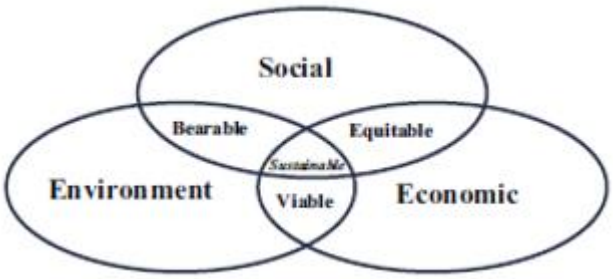

Figure 6. The sustainability dimensions based on the triple bottom line approach (TBL).

Port sustainability requires a holistic and integrated approach (Hiranandani, 2014; Le et al., 2014; Yap and Lam, 2013). As discussed before, the capitalizing on economic opportunities and cost savings offered by environmentally friendly operations can support sustainable development in port operations (Hiranandani, 2014; Asgari et al., 2014; Dinwoodie et al., 2014; Lam and Van de Voorde, 2012). In addition, policies must be based on stakeholder involvement and public-private partnerships including shippers, port-related businesses, and the local and global community (Dooms and Macharis, 2003; Hiranandani, 2014; Le et al., 2014). According to Denktas-Sakar and Karatas-Cetin (2012), the higher the level of coordination and integration among the stakeholders of port and supply chains, the higher the level of sustainability of the entire supply chain and of the port is. Effective stakeholder engagement, however, requires a concrete plan for involving the stakeholders and proactive support from the port authorities (Le et al., 2014; Kuznetsov et al., 2015). Based on the literature review, port sustainability therefore commonly implies to "business strategies and activities that meet the current and future needs of the enterprise and stakeholders, whilst protecting human and natural resources" (Hiranandani, 2014).

Some of the studies, however, remain critical of the TBL approach to sustainability: Kuznetsov et al. (2015) criticize the TBL approach for presenting a generalization of the principles rather than a definition of sustainability and therefore offering only limited practical applications. The developed Port Sustainability Management System (PSMS) framework, on the other hand, accounts for the practical applications and has a proactive approach to sustainability assessment (Kuznetsov et al., 2015). Similarly, in the 30MILES project, the use of Bayesian decision modelling based on set of sustainability indicators can provide a new method to assessing port sustainability. Furthermore, the development of just sustainability (JS) criteria and the incorporation of such indicators into sustainability assessments could add to the sustainability of large scale projects such as ports (Ditty

and Rezende, 2014). Just sustainability relies on three requirements including the presence of equitable resource allocation between stakeholders, recognition of the intrinsic value and life experiences of all involved parties, and the meaningful participation of stakeholders in the decision-making process (Schlosberg, 2004).

4. Conclusion

Based on the literature review, stakeholder involvement and incorporating business operations with environmentally friendly practices can support and foster sustainable development in port operations (Hiranandani, 2014). However, there is a clear need for more research on sustainable recreational ports, and need for developing a practical framework for sustainability assessment of small ports (Kuznetsov et al., 2015). Therefore, within the 30MILES project, the Fisheries and Environmental Management group (University of Helsinki) a Bayesian decision model will be developed for making sustainable development plans for the 11 ports in the Eastern Gulf of Finland. The model will be used for future investments of ports.

In the decision model, sustainability is seen as a three-dimensional issue, covering the aspects of environmental impacts of ports, sustainable business development and accessibility and safety of ports. Sustainability can be reached in the equilibrium of these factors and the alternative stabile states are searched with the help of modelling. Further research is needed on to what extend the model can provide a unified response to port sustainability or if it is to be port-specific.

Data for the model will be collected among different stakeholder groups with the use of on-line questionnaires, individual interviews, and focus group interviews. The online questionnaire targets the port visitors: the aim is to find what attracts the visitors and what services the ports should invest in. The questionnaire considers the three dimensions of port sustainability.

Finally, based on the Bayesian decision model, a set of indicators for port sustainability will be defined for the recreational ports within the 30MILES project. The system of indicators can be further developed into a sustainability certification for the ports. The indicators will consider the environmental impact of ports, port profile and environmental management system of ports. The indicators will provide the port authorities a practical way of self-assessing the sustainability of ports and are based on continuous improvement and re-assessing.

In addition, further research is needed on transparency, accountability and the legal and regulatory environment for public-private partnerships, and on the possible conflicts within public-private

parterships (Hiranandani, 2014) as well as on how to encourage public participation in decision-making in order to help both the port's management and the public in fostering meaningful participation (Le et al 2014; Ditty and Rezende, 2014).

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