

# IMPLEMENTING SUSTAINABLE DEVELOPMENT IN PORT-CITIES

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**ABSTRACT:** Sustainable development in port-cities is a key area of priority if the United Nations' Sustainable Development Goals are to be achieved, and the worst-case scenarios for climate change avoided. This research paper presents the findings of two 4-year research projects relating to port-cities and shipping, which are the port-cities of the future project undertaken by Ramboll and the University of Southampton, and the EU Horizon 2020 funded EMERGE research project. This produced 5 recommendations for implementing sustainable development in port-cities. These are to increase port and city cooperation, implement the circular economy, increase adoption of renewable energy, reduce pollution, and increase the social benefits created by the port for the city. These recommendations contribute to the sustainable development goals and help address the unique challenges faced by port-cities.

Keywords: Port-Cities, Sustainable development, Circular economy, Pollution, Climate change, Scrubbers

## 1. INTRODUCTION

History is full of examples of port-cities that failed to adapt to change and entered a period of decline, and with examples that embraced new opportunities and thrived. The fate of a port-city is strongly tied to the successes and failures of the port. The last centuries have seen a substantial increase in the number of people living in cities, increasing to 55% of the human population in 2018, and expected to reach 68% by 2050 (United Nations, 2018). Accompanying this trend of urbanisation, has been the dramatic growth of coastal cities, which have seen the fastest rates of growth (Adomaitis, 2014). Despite the attraction of port-cities, the relationships between ports and cities have become increasingly strained, as increasing port activity has created a greater number of negative impacts for local people, such as traffic congestion, visual blight, community severance and pollution (OECD, 2013). This is especially an issue in port-cities with privatised ports, which often results in the port and city being completely cut off from each other, both physically and institutionally, resulting in areas of tension, competing objectives and a lack of positive relationships (Galvao et al, 2016). This has occurred at the same time as decreasing port-related employment, increasing automation and a wider geographical spread of port-related economic activity, such as manufacturing, has seen local economic benefits and local employment decline (OECD, 2013). Local people have to experience these negative impacts on a daily basis, whilst experiencing increasingly fewer benefits. The level of support for port operations from the local people, known as the societal license to operate (Moeremans and Dooms, 2021) has become increasingly important in securing a port's long term future, with ports increasingly aware of the fact improving relations with local people is of critical importance (ESPO 2020). A process known as demaritimisation (Musso and Ghiara, 2011) has seen cities become increasingly disconnected from the port and its benefits, with port-cities losing their unique maritime identities and the ports influence on local culture declining. Cities have in many cases lost their connection to the benefits of port activity, whilst being increasingly impacted by the negatives port activity creates (Roberts et al. (2021b). Port-cities are therefore in desperate need of sustainable development,

in order to provide the social and economic benefits required to maintain the societal license to operate, whilst reducing the negative environmental impacts port activity creates, and ideally creating environmental benefits, with work such as Chen and Lam (2018) highlighting the need for sustainable development in port-cities.

Climate change and sustainability present the greatest challenge port-cities will face this century. The increasingly certainty of at least 1.5°C of global temperature rise, and a potentially greater than 2°C rise (Meinshausen et al, 2022), and sea level rise measured in metres rather than cm by the end of this century (Horton et al, 2020) means that many of the world's port-cities face an incredibly uncertain long-term future. In the shorter term, port-cities must be key areas of attention if the worst-case scenarios for climate change are to be avoided, and meaningful progress towards the sustainable development goals is to be achieved.

Port-cities are on the frontlines of many of the key challenges of modern times, such as urbanisation, globalisation, climate change impacts and sustainability challenges. They are uniquely placed to experience considerable negative impacts from climate change such as sea level rise, increased storminess, increased coastal erosion, salt-water intrusion into fresh water supplies, poverty and displacement of people, biodiversity loss, resource depletion, shifting trade patterns and geopolitical issues. They are also potential hotspots of environmental pollution, due to pollution from ships, port related traffic and industry, as well as being located near to vulnerable marine and terrestrial environments, such as RAMSAR sites and marine protected areas (Teschner, 2019).

Despite these challenges, port-cities are ideally placed to lead this transition to a more sustainable world. As centres of industry, waste products and potential consumers, they are ideally placed to implement the circular economy (De Langen and Sornn-Friese, 2019). This transition risks leaving certain ports that fail to embrace it behind, due to a decrease in imports of certain raw materials, and a potential increase in localised supply chains not requiring as much international shipping. Ports that are reliant on the fossil fuel industry also face an uncertain future, and risk entering decline if they are slow to react to changes. Their coastal location presents numerous opportunities for environmental improvements, such as renewable energy. Sustainable development can create significant opportunities for ports, and those that face up to this challenge will be best positioned to thrive. Cities are places where the battle for a more sustainable world will be won or lost, and port-cities are often the places where these challenges are most strongly faced, making them the most important of battlegrounds. Port-cities therefore stand at cross-roads, they can either embrace sustainability, or risk being left behind.

This paper will introduce recommendations for sustainable development in port-cities by presenting the key findings of two 4-year funded research projects. These are the port-cities of the future research project funded by Ramboll and the University of Southampton, and the European Union's Horizon 2020-funded project "Evaluation, control and mitigation of the environmental impacts of shipping emissions" (EMERGE). These two projects provide a comprehensive overview of a range of social, economic, and environmental issues pertaining to port-cities and shipping.

## **2. BACKGROUND**

### **2.1 Port-cities of the future**

The port-cities of the future project aimed to create sustainable development guidance for port-cities, and was conducted by distributing an online questionnaire covering a range of social, economic and environmental issues to professionals employed by port authorities in 26 countries (Albania, Australia, Belgium, Belize, Brazil, Egypt, Canada, Chile, China, Finland, France, Japan, Latvia, Morocco, Namibia,

Netherlands, Portugal, Romania, Saudi Arabia, Singapore, South Korea, Spain, Sri Lanka, Togo, UK and the USA). A separate online questionnaire was distributed to senior professionals working for city authorities in 13 countries (Australia, Bangladesh, Chile, China, France, Nigeria, Pakistan, South Korea, Sri Lanka, Turkey, UK, USA, Vietnam). These countries are shown in Figure 1. The findings of the project are presented in Roberts et al. (2020), Roberts et al. (2021a), Roberts et al. (2021b), Ramboll 2022, Roberts et al. (2022), Roberts et al. (2023) and Roberts (2024).



Figure 1. Locations of study respondents (shown in red).

This study used the Southampton System to group port-cities into several types, with the size of the settlement being defined as a town (10,000-99,000 inhabitants), a city (100,000-999,999 inhabitants), a metropolis (one million to 9.9 million inhabitants) and a mega-city (more than ten million). The size of a port is defined as micro (100 Kilotonnes to 999 Kilotonnes or 10,000 passengers to 99,999 passengers.), small (1,000 Kilotonnes to 9,999 Kilotonnes or 100,000 Passengers to 999,999 passengers), medium (10,000 Kilotonnes to 99,999 Kilotonnes or 1 million Passengers to 9.9 million passengers), and Large (100,000 Kilotonnes + or 10 million passengers +). This system is presented in Figure 2.

## 2.2 The EMERGE project

EMERGE is a 4-year project funded by the European Union's Horizon 2020 research and innovation programme. It aims to systematically analyse the complex interactions between technological options for pollution reduction, pollutant emissions and dispersion, and the environment. This especially focuses on the effectiveness of exhaust gas cleaning systems (EGCS), or scrubbers, used on ships to reduce pollutants, and the impact the discharge of the resulting wash water may have on the marine environment.

This was conducted via a range of published methods. This data was collected in five case study areas: The Aveiro region, The Solent Straight including Southampton and Portsmouth, the city of Venice, Italy, and northern Adriatic Sea, the Oresund Straight and the port of Piraeus, Greece, and Eastern Mediterranean. In addition, on-board ship sampling was conducted in the Mediterranean and other European Sea regions. These are presented in Figure 3.

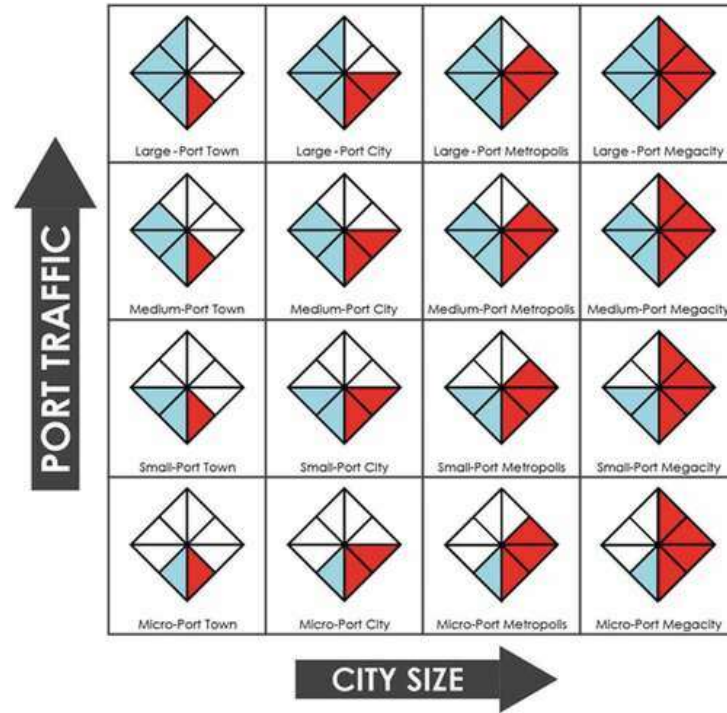


Figure 2. The Southampton System for port-city classification (Roberts et al. 2020).

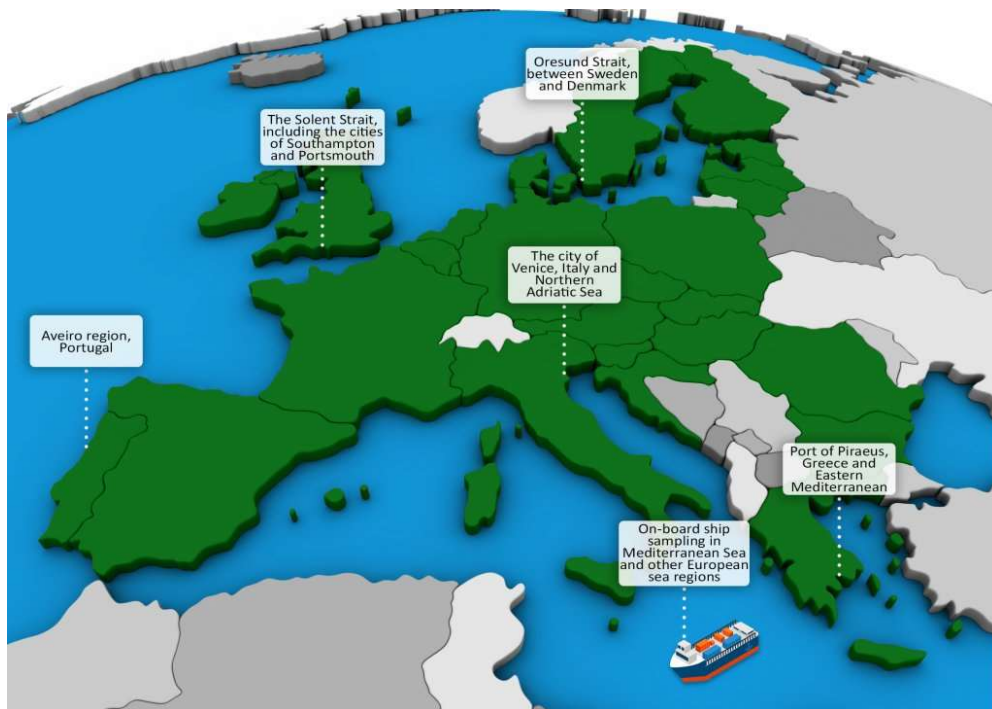


Figure 3. EMERGE case study locations (from <https://emerge-h2020.eu/about-emerge/>).

### 3. EMERGE PROJECT

The key findings of these two research projects are presented in Table 1, spread across social, economic, environmental, and general findings. These two projects bring together a global sample of port and city authorities, and a comprehensive study of shipping pollution to create recommendations based on the latest scientific findings that are supported by the views of port and city authorities.

Table 1. Key findings of research projects.

	Key finding	Sources
Social	<p>Recognition from port authorities that ports face increasing pressure from local residents to reduce negative impacts.</p> <p>Maritime museums and port access highlighted as potentially effective options for improving local attitudes.</p> <p>High levels of interest in creating port centres (a designated building to provide port related information and activities to the public).</p> <p>Social issues and adoption of measures is lowest in medium-sized ports.</p> <p>Adoption of measures varies across groups.</p> <p>Medium-sized ports experience the worst relationships with city authorities.</p>	<p>Roberts et al. (2021b)</p> <p>Ramboll (2022)</p> <p>Roberts (2024)</p>
Economic	<p>Preference for port diversification instead of specialisation.</p> <p>High levels of support for the circular economy from both port and city authorities.</p> <p>Port authorities desire industrial development.</p> <p>Land-use a considerable source of tension between port and city authorities.</p> <p>Close proximity between port and cities has been shown to lead to an increase in perceived tension regarding land use.</p> <p>Ports wish to expand in their current locations, rather than relocate.</p> <p>Shipping companies that have invested in exhaust gas cleaning systems have already paid off the costs of implementation due to being able to continue to use cheaper fuel.</p>	<p>Roberts et al. (2021a)</p> <p>Ramboll (2022)</p> <p>Roberts (2024)</p> <p>Jalkanen <i>et al</i> (2024)</p>
Environmental	<p>Water pollution is number 1 environmental priority of port authorities globally, followed by air pollution.</p> <p>For cities, air pollution is the number 1 priority, followed by water pollution.</p> <p>Despite ports regarding waste as a prominent issue, the majority of port authorities lack specific recycling plans.</p> <p>High levels of interest in renewable energy, electric port equipment, electric port and harbour vessels, building efficiency improvements and shore to ship power amongst port authorities and city authorities.</p> <p>Medium-sized ports have lowest levels of implementation of measures, suggesting they face greater barriers to implementation.</p> <p>The negative impacts of wash water discharges from exhaust gas cleaning systems (open-loop scrubbers) used to reduce air pollution from ships outweighs the human health benefits produced by the improved air quality.</p>	<p>Roberts et al. (2023).</p> <p>Jalkanen <i>et al</i> (2024).</p>
General	<p>City authorities may lack awareness about port activities and currently implemented measures, and this awareness deteriorates as city size increases.</p>	<p>Roberts (2024).</p>

The findings presented identify social, economic, and environmental issues that can be addressed with five recommendations that should be prioritised to reduce the negative impacts of ports on cities and the environment, and increase the local benefits ports create. This should help port-cities work towards sustainable development and contribute to the sustainable development goals. These are presented below.

#### 3.1 Recommendation 1. Increase port and city cooperation.

A lack of cooperation between ports and cities is at the heart of many of the key issues port-cities face, and improvement is made more difficult if port and city authorities do not work together. Roberts (2024)

has identified a key issue, which is the fact that not only is there a lack of cooperation and consistency, but the current structures are not conducive for allowing that cooperation to take place as cities appear to be less aware of port operations as city size increases. Many city authorities lack specific personnel with expertise relating to the totality of the ports relations with the city, with expertise relating to the port spread out across departments and fragmented. This suggests that cooperation between ports and cities would only be possible in many cases on a piecemeal basis. Sustainable development requires coordination between all areas and the elimination of this fragmentation, not just within the city authorities, but between all port-city-related stakeholders. A good example of this is the implementation of the circular economy, which requires linkages between stakeholders and industries, effective networking, and information sharing.

Ports and cities should consider conducting joint planning, such as long-term masterplans, rather than creating plans entirely in isolation. A good example of the issues created by planning in isolation can be provided by the Southampton City Council's local NO<sub>2</sub> plan (Southampton City Council 2022), which hopes to improve NO<sub>2</sub> levels in Southampton by focusing only on issues outside the port area, such as reducing emissions from buses, and encouraging low emission taxis. This is clearly insufficient in a city with port activity at the scale of Southampton. Greater cooperation between ports and cities is essential if issues such as traffic congestion are to be addressed, with a key potential solution to this being increasing the amount of freight transported by rail. If this requires additional infrastructure to be built, then cooperation between port and city authorities is essential.

Key SDGs targeted:

- Goal 17. Target 17: Encourage effective partnerships

Increased port-city cooperation is a key factor in enabling the following recommendations.

### **3.2 Recommendation 2. Work towards the circular economy.**

If sustainable development is to be achieved, then a complete transformation of society is necessary across all sectors. The transition from a linear economy to a circular economy is one aspect of this transformation that is not only essential but also able to provide considerable social, environmental, and economic benefits. Port-cities are ideally located to be at the epicentre of this transition, with Kalundborg eco-industrial park (Denmark) providing a good example of this (Kalundborg Symbiosis, 2020). Roberts et al. (2021a) identified that current levels of adoption of the circular economy are low, but port authorities globally have an elevated level of interest in increasing implementation.

The introduction of a circular economy allows ports to diversify their operations as desired (Ramboll 2022), whilst reducing their negative environmental impact. If ports are to pursue the industrial development they desire, then circular economy principles must be applied to manage the negative impacts this creates. This could be achieved by using the circular economy framework outlined in Roberts et al. (2021), which creates an annual review involving port and city stakeholders, requiring them to work towards incremental and continual annual progress, similar to an environmental management system. The port-city circular economy framework provides a potential approach for port-cities to begin to overcome the barriers to circular economy such as a lack of leadership, information sharing and networking (Hart et al., 2019) and start to implement the circular economy. It would also create a local waste inventory, establishing the foundations of a circular marketplace enabling local businesses to buy and sell waste products. This framework could also be used to help establish research partnerships and collaboration with universities, accreditation bodies, tech SMEs, Business Parks, Innovation Hubs, Port ecosystems, clusters etc.

Key SDGs targeted:

- Goal 8. Target 4: Improve resource efficiency in consumption and production.
- Goal 9. Target 1: Develop sustainable, resilient, and inclusive infrastructures

Target 2: Promote inclusive and sustainable industrialization

Target 4: Upgrade all industries and infrastructures for sustainability

- Goal 11. Target 6: Reduce the environmental impacts of cities
- Goal 12. Target 2: Sustainable management and use of natural resources

Target 4: Responsible management of chemicals and waste

Target 5: Reduce waste generation

Target 6: Encourage companies to adopt sustainable practices and sustainability reporting

Target 8: Promote universal understanding of sustainable lifestyles

- Goal 17. Target 17: Encourage effective partnerships

### **3.3 Recommendation 3. Increase adoption of renewable energy**

The desire for port diversification can be used to introduce beneficial services, such as increased usage of renewable energy. Ports can invest in this as an extra service, such as off-shore wind farms. Ports are in an ideal location to introduce renewable energy and can benefit from doing so, with numerous examples of this already being in place such as the port of Amsterdam and the port of Cherbourg (Wind Europe, 2022). Renewable energy enjoys support from both port and city authorities and would be a suitable approach to balance the ports desire for diversification with the city's desire for environmental improvements and quality of life requirements. This can provide global benefits by enabling the transition away from fossil fuels, as well as local benefits such as reducing other forms of air pollution, generating clean energy, and creating employment in the local area. This helps provide environmental, economic, and social improvements to the local area, making it an excellent example of sustainable development. If the transition to renewable energy is to be achieved then ports should be encouraged to not seek to preserve the status-quo by using technologies designed to enable their continued use, such as exhaust gas cleaning systems.

Key SDGs targeted:

- Goal 3. Target 9: Reduce illnesses and deaths from hazardous chemicals and pollution
- Goal 7. Target 1: Universal access to modern energy

Target 2: Increase global percentage of renewable energy

- Goal 13. Target 2: Integrate climate change measures into policy and planning

### **3.4 Recommendation 4. Reduce pollution.**

The pollution created by ports is one of the largest negative impacts they create for the local area and addressing this must be a priority for port-cities in the future. There is a clear preference for port expansion

and for this expansion to take place without relocating a port. If a port is to continue to grow, then the pollution created by port activity has to be mitigated if the port is to maintain its societal license to operate.

Electric port equipment, electric port, and harbour vessels, building efficiency improvements and shore-to-ship power all enjoy support amongst port and city authorities, and should therefore be pursued as effective ways to reduce the pollution created by port activity. The key barriers to these measures could be reduced if port and city cooperation is increased, highlighting the importance of cooperation. At present, medium-sized ports contain the lowest levels of adoption, suggesting that this size of port may face barriers due to land use and finances, which could be improved with guidance 1. Medium sized ports should be areas of priority, where environmental protection is currently lacking. Adoption of certain measures is linked to port size, such as shore-to-ship power, vessel speed reduction, LNG, and emissions control areas. This suggests that smaller ports face significant barriers to adoption, such as an insufficient business case for shore-to-ship power for example. Electric port equipment, electric port and harbour vessels and building efficiency improvements may therefore be the most suitable measures to encourage in micro, small and medium sized ports. Cities also become increasingly unaware of which measures have been adopted by the port as city size increases, again highlighting the importance of greater cooperation and information sharing.

Open-loop scrubbers (EGCS) have also been shown to create negative environmental impacts for the marine environment. The improvements in air quality using such systems comes at a cost to the marine environment. It is not the case that this cost is inevitable, as closed-loop scrubbers and alternative fuels already exist. Roberts et al. (2023) highlights how water pollution is the top priority for port authorities globally, and the 2<sup>nd</sup> environmental priority for city authorities only behind air pollution. Creating a new source of water pollution is therefore undesirable if these authorities are to achieve their targets and ambitions. Considering the fact that investments in open-loop scrubbers have already produced significant cost savings from using cheaper fuel and the cost of this technology has been paid off (Jalkanen *et al*, 2024), it is now time to transition away from these systems, ceasing their use entirely. The IMO (2019) has highlighted a lack of wastewater reception facilities in ports as a key issue, and Roberts et al. (2021b) has also identified land-use as a key challenge for port and city relationships, suggesting increasing these facilities may be challenging. Therefore, switching to closed-loop scrubbers, whilst better for the marine environment, may also create further problems, in addition to prolonging the usage of fossil fuels. Ports should therefore be proactive and encourage greater adoption of cleaner fuels and alternative sources of energy, rather than finding ways to preserve the status-quo.

Key SDGs targeted:

- Goal 3. Target 9: Reduce illnesses and deaths from hazardous chemicals and pollution
- Goal 6. Target 6: Protect and restore water-related ecosystems
- Goal 14. Target 1: Reduce marine pollution

Target 2: Protect and restore ecosystems

Target 5: Conserve coastal and marine areas

- Goal 15. Target 1: Conserve and restore terrestrial and freshwater ecosystems

Target 5: Protect biodiversity and natural habitats



### 3.5 Recommendation 5. Increase the social benefits of ports.

The social dimension of sustainable development is often neglected; however, it is important that port-cities better capitalise on their considerable potential to provide social benefits for their local populations. Successful port-cities are those which can benefit from their maritime heritage and create a unique sense of identity which is beneficial for local wellbeing as well as providing additional tourism, and in many cases the revival of a declining port-city has been driven by maximising the benefits provided by maritime heritage, such as historic locations, waterfront access and museums. This can help reverse the trend of demaritimisation noted by Musso and Ghiara (2011).

Maritime museums and port access, such as boat tours or cycle paths, could be introduced as proven methods for improving the ports perceptions of resident's attitudes towards the port. Port centres can also be introduced to raise awareness of the benefits the port creates and the role it plays within the port-city. It will be beneficial for city authorities to involve themselves in this, and collaborate with ports to create port-city centres, which could provide the same services as a port centre whilst adding additional services, such as providing a focal point for increased awareness of port-city issues, information sharing, networking, and a neutral venue from which to pursue joint projects. Maritime museums should be prioritised in mega-cities, as they are currently largely absent, whereas port centres could be encouraged in cities and metropolises. The city size group also has the lowest levels of adoption, with port events, port information and social media and education all at their lowest level in the city size group. Medium-port cities also experience similar issues, reporting the lowest levels of adoption and poorer relations with city authorities. Increasing city size is also shown to lead to a lack of awareness from the city authorities of the port's measures to address social issues, as well as metropolises and mega-cities being more likely to believe the local population are not aware of the benefits the port provides and more likely to believe they have negative views of the port. Measures to improve social attitudes therefore should be prioritised in medium sized ports and above, and the city size group and above. Port-cities containing medium size ports and/or urban settlements grouped into the city size group are areas that need to prioritise addressing these issues.

This recommendation is more difficult to relate clearly to an SDG, but it should provide increased mental wellbeing for local residents and an improved quality of life and sense of local pride, education about the role of the port within the city and increased benefits from marine resources such as via tourism by encouraging maritime museums. Raising awareness of the importance of the role of the port and the benefits of the relationship between port and city should encourage an awareness of the value this provides, and the benefits created by a healthy and well-protected coastal and marine environment. The social aspect of sustainable development is often neglected and most of the SDGs focusing on this are targeted at developing countries, therefore they may not consider the benefits created by this approach in already developed countries.

Key SDGs targeted:

- Goal 3. Target 4: Reduce mortality from non-communicable diseases and promote mental health
- Goal 4. Target 7: Education for sustainable development and global citizenship
- Goal 14. Target 7: Increase the economic benefits from sustainable use of marine resources

## 4. CONCLUSIONS AND RECOMMENDATIONS

These research projects identify areas for increasing sustainable development in port-cities. These recommendations allow future port-city development to be focused on areas that are of interest to port

and city authorities and allow the port to continue to thrive and grow, whilst managing the negative impact ports create and increasing the local benefits they produce. This should allow port-cities to work towards sustainable development and maintaining and strengthening their societal license to operate. Whilst these recommendations would not remove the negative impacts ports create entirely, and certain issues relating to the ships themselves remain, they should provide a clear path towards more sustainable port-cities and lay the foundations for further work to expand upon.

Technologies such as open-loop scrubbers that create new sources of negative environmental impacts should be prohibited entirely to prevent further damage to the marine environment, with the port and shipping industry instead being encouraged to prioritise cleaner fuels and sources of energy. Port-cities have an opportunity to lead the transition to a more sustainable world, and it is therefore important that they lend their voices to the most ambitious of changes, rather than technologies that produce further negative impacts for the environment.

These findings mostly focus on top-down governance within port-cities from the perspectives of city and port authorities, and how this can be harnessed to facilitate sustainable development. Further work could explore aspects relating to funding, infrastructure, and bottom-up governance, as highlighted by Kennedy et al. (2005), as the four pillars of sustainable urban transportation, alongside top-down governance. This could involve working with port user communities, shipping lines, freight forwarders and other stakeholder groups, as well as identifying sources of funding such as road user charging or land value capture.

Due to this paper's focus on the sustainable development goals, with a target date of 2030, longer term issues such as sea-level rise are not covered by these recommendations. In the long term, deep adaptation to climate change as proposed by Monios and Wilmsmeier (2020) should be adopted, preparing for disruptive and uncontrollable levels of climate change which may completely undermine the viability of many port-cities to exist in their current locations.

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