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MACI JOURNAL OF MULTIDISCIPLINARY ADAPTIVE CLIMATE INSIGHTS

Multidisciplinary Adaptive Climate Insights (MACI) journal is an open access biannual international peer-reviewed publication providing a global platform for the dissemination of research articles, case studies, and reviews across diverse disciplines, focusing on the multifaceted impacts of climate change and the integration of adaptive measures.

Our journal strives to contribute essential research findings to the international community, aiding researchers, scientists, institutions, and societies in staying abreast of new developments in theory and applications. We welcome experimental, computational, and theoretical studies that enrich the understanding of climate-related challenges.

Focal areas of interest include, but are not limited to, climate adaptation, mitigation strategies, interdisciplinary studies, climate trends, climate data analysis, climate modeling, climate economics, and the impact of climate change on agriculture, water resources, health, and the environment. We emphasize the integration of climate science into various fields and the collaboration needed to address the complex challenges posed by climate change.

Sustainable development is at the core of our mission. We believe in meeting human development goals while preserving the capacity of natural systems to provide essential resources and ecosystem services. Case studies exploring the intersection of sustainable development and climate challenges are particularly encouraged.

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CLIMATE CHANGE: INTERDISCIPLINARY SOLUTIONS FOR A GLOBAL CHALLENGE

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EDITORIAL

ABSTRACT:

Climate change, driven by human activities like fossil fuel combustion and deforestation, leads to global warming with far-reaching impacts such as rising sea levels, extreme weather events, and disruptions to ecosystems and human health. Addressing this issue requires a multidisciplinary approach, integrating environmental science, economics, engineering, social sciences, and public policy.

This article highlights the need for interdisciplinary collaboration to develop comprehensive strategies for mitigating and adapting to climate change. Environmental scientists provide crucial data, economists analyze costs and benefits, engineers develop innovative solutions, and social scientists explore human dimensions. Successful examples of interdisciplinary efforts include ecosystem-based fisheries management, which balances ecological sustainability with economic viability.

Advanced climate models, such as General Circulation Models (GCMs) and Earth System Models (ESMs), informed by high-quality data, are essential for predicting climate impacts and informing policy decisions. Proactive climate action, including the transition to renewable energy and improved energy efficiency, can yield significant economic benefits and prevent future losses.

Key sectors affected by climate change—agriculture, water resources, health, environment, and maritime transport—require tailored solutions to mitigate impacts and enhance resilience. For instance, developing drought-resistant crops and efficient irrigation techniques can secure agricultural productivity and address water scarcity.

In conclusion, addressing climate change demands an interdisciplinary approach and international cooperation. By leveraging diverse expertise and fostering global collaboration, we can develop innovative solutions for a sustainable future.

KEY-WORDS: Climate Change, Interdisciplinary Approach, Climate Mitigation, Climate Adaptation, Sustainable Development.

1. INTRODUCTION

Climate change is one of the most pressing and complex global issues of our time. It is characterized by significant and enduring changes in the Earth's climate system, driven primarily by human activities such as the burning of fossil fuels, deforestation, and various industrial processes. These activities increase the concentration of greenhouse gases in the atmosphere, leading to global warming. The consequences of climate change are far-reaching and include rising sea levels, more frequent and severe extreme weather events, shifts in ecosystems and biodiversity, and adverse impacts on human health and economies (IPCC, 2021).

Addressing climate change is not only an environmental imperative but also a socio-economic challenge that requires coordinated global action. The impacts of climate change are pervasive, affecting nearly every aspect of life on Earth. From the melting ice caps and rising ocean temperatures to the increased frequency of hurricanes, droughts, and wildfires, the signs of climate change are evident and growing more severe each year. Furthermore, climate change exacerbates existing social inequalities, disproportionately affecting vulnerable populations in low-income regions who have the least capacity to adapt (UNFCCC, 2020).

Given the multifaceted nature of climate change, a multidisciplinary approach is essential in addressing its challenges effectively. This approach integrates insights and methodologies from various fields, including environmental science, economics, engineering, social sciences, and public policy. By leveraging the strengths of different disciplines, we can develop more comprehensive and effective strategies to mitigate and adapt to climate change (Moser & Dilling, 2007).

For instance, environmental scientists provide critical data on the physical and biological impacts of climate change, while economists evaluate the costs and benefits of mitigation and adaptation strategies. Engineers and technologists develop innovative solutions to reduce greenhouse gas emissions and enhance energy efficiency. Meanwhile, social scientists investigate the human dimensions of climate change, such as public perceptions, behaviors, and the social impacts of climate policies. Policy experts synthesize this knowledge to create robust, evidence-based policies that can drive systemic change (Ostrom, 2009).

A multidisciplinary approach also facilitates the development of collaborative solutions that are more resilient and adaptable. For example, the integration of ecological data with economic models can help manage natural resources more sustainably, ensuring that conservation efforts are both environmentally and economically viable. Similarly, combining technological innovations with social science insights can improve the acceptance and effectiveness of new climate technologies among diverse communities.

In conclusion, climate change is a complex and multifaceted challenge that requires a multidisciplinary approach to address effectively. By drawing on the expertise of various fields, we can develop innovative and comprehensive solutions that consider the ecological, economic, and social dimensions of this global issue. This collaborative effort is essential for mitigating the impacts of climate change and promoting sustainable development for future generations.

2. INTERDISCIPLINARY COLLABORATION

2.1. Explanation of How Different Fields Can Work Together to Solve Climate Challenges

Addressing the complex and multifaceted issue of climate change necessitates the integration of knowledge and methods from various disciplines. Interdisciplinary collaboration enables the development of comprehensive solutions that consider ecological, economic, social, and technological aspects. By combining expertise from different fields, researchers and policymakers can tackle climate challenges more effectively and holistically.

Environmental science provides critical insights into the physical and biological impacts of climate change, offering data on temperature changes, sea level rise, and biodiversity loss (Parmesan et al., 2013). Economists contribute by assessing the economic costs and benefits of various mitigation and adaptation strategies, helping to identify cost-effective measures that can reduce greenhouse gas emissions and support sustainable development (Stern, 2007). Engineers and technologists play a vital role in developing innovative solutions, such as renewable energy technologies, energy-efficient systems, and carbon capture and storage methods, which are essential for reducing emissions and transitioning to a low-carbon economy (Benson & Cole, 2008).

Social scientists add another critical dimension by studying human behavior, societal impacts, and public perception of climate change. Their research helps in understanding how communities perceive and respond to climate policies, which is crucial for designing effective and equitable interventions (Nisbet, 2009). Additionally, public policy experts synthesize knowledge from these various disciplines to formulate and implement policies that address the root causes of climate change and promote resilience and adaptation (Goulder & Parry, 2008).

2.2. Example of Successful Collaboration

A notable example of successful interdisciplinary collaboration can be seen in the integration of marine ecology and economics to manage fisheries sustainably. Marine ecologists study the health and dynamics of marine ecosystems, providing essential data on fish populations, habitat conditions, and ecological interactions. Economists use this data to develop models that evaluate the economic impacts of different fishing practices and management strategies.

One successful collaboration in this field is the work on ecosystem-based fisheries management (EBFM). EBFM integrates ecological data with economic analysis to create management plans that balance ecological sustainability with economic viability. For instance, by setting catch limits based on ecological data, fisheries can prevent overfishing and ensure the long-term health of fish populations. At the same time, economic analysis helps in designing policies that support the livelihoods of fishing communities, making sustainable practices more attractive and feasible (Pikitch et al., 2004).

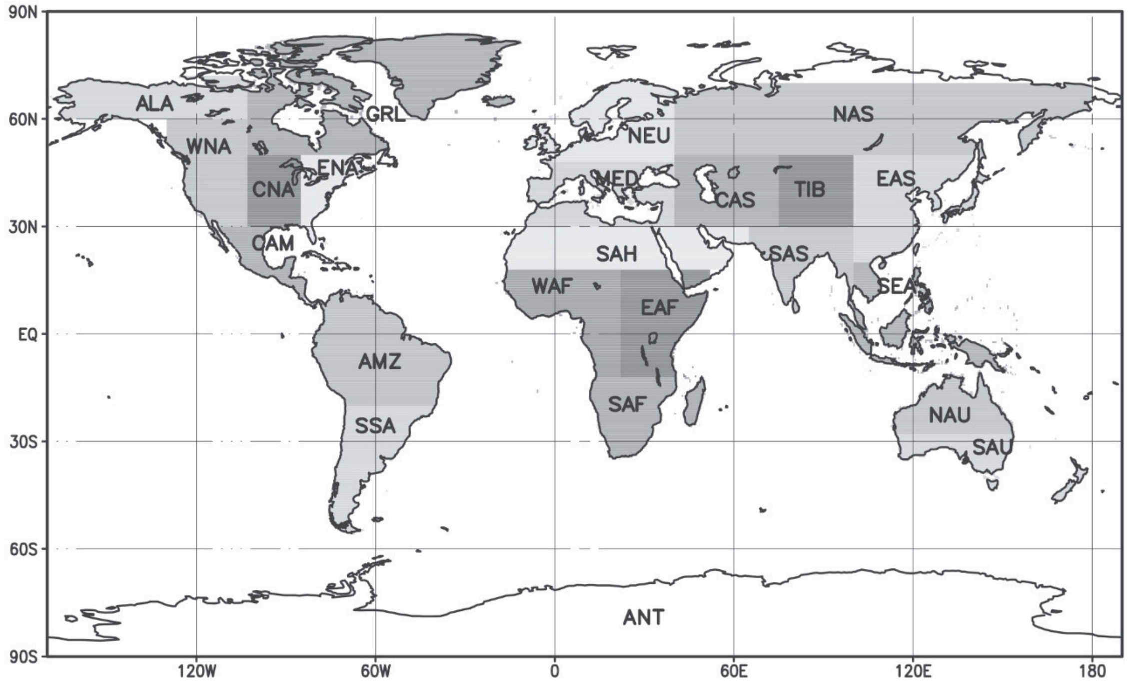
The collaboration between marine ecologists and economists has led to the development of tools such as bioeconomic models, which are used to predict the outcomes of different management strategies. These models take into account both the biological dynamics of fish populations and the economic behavior of fishers, providing a more comprehensive understanding of the impacts of various policies. The success of such interdisciplinary efforts demonstrates the power of combining expertise from different fields to address complex environmental challenges (Hilborn, 2007).

3. ADVANCED CLIMATE MODELING

3.1. Description of Current Climate Modeling Techniques

Climate modeling has become a cornerstone in understanding and predicting climate change. Current climate modeling techniques use complex computer simulations to represent the interactions between the atmosphere, oceans, land surface, and ice. These models, known as General Circulation Models (GCMs), are based on physical laws expressed through mathematical equations that simulate atmospheric processes, ocean currents, and land surface interactions over time (Randall et al., 2007).

GCMs have evolved to include higher spatial resolution and more detailed representations of physical processes, allowing for more precise simulations of climate dynamics. In addition to GCMs, Earth System Models (ESMs) incorporate biogeochemical cycles, including carbon and nitrogen cycles, to provide a more comprehensive understanding of climate feedback mechanisms (Collins et al., 2011). Regional Climate Models (RCMs) are also employed to downscale global model outputs to provide more detailed projections at regional and local scales, which are crucial for impact assessments and planning (Giorgi et al., 2009).



ALA	Alaska	NEU	Northern Europe	NAS	Northern Asia
WNA	Western North America	MED	Mediterranean	TIB	Tibet
CNA	Central North America	CAS	Central Asia	EAS	Eastern Asia
ENA	Eastern North America	SAH	Sahara	SAS	Southern Asia
GRL	Greenland	WAF	West Africa	SEA	South East Asia
CAM	Central America	EAF	East Africa	NAU	Northern Australia
AMZ	Amazonia	SAF	Southern Africa	SAU	Southern Australia
SSA	Southern South America	ANT	Antarctic		

Fig. (1): Map showing regional climate change projections and impacts, essential for understanding localized effects and planning.
Source: Giorgi et al. (2009)

3.2. Importance of Data-Driven Insights for Accurate Climate Predictions

The accuracy and reliability of climate predictions depend heavily on data-driven insights. High-quality observational data from satellites, weather stations, and ocean buoys are essential for initializing models and validating their outputs. This data helps improve the representation of current climate conditions and enhances the predictive capabilities of models (Hansen et al., 2010).

Data-driven insights enable the identification of trends, patterns, and anomalies in climate variables, which are critical for refining models and reducing uncertainties. For instance, data on sea surface temperatures, atmospheric composition, and ice sheet dynamics provide vital inputs for simulating future climate scenarios. The continuous integration of new data helps to update and improve models, making predictions more robust and reliable (Thorne et al., 2011).

3.3. Example of How Modeling Informs Policy Decisions

Climate models play a crucial role in informing policy decisions by providing scientific evidence on the potential impacts of climate change and the effectiveness of mitigation and adaptation strategies. For example, the Intergovernmental Panel on Climate Change (IPCC) relies heavily on climate models to produce its assessment reports, which are instrumental in shaping international climate policy (IPCC, 2014).

One notable example is the use of climate modeling to inform the Paris Agreement, an international treaty aimed at limiting global warming to well below 2°C above pre-industrial levels. Climate models were used to project the long-term impacts of different greenhouse gas emission scenarios, helping policymakers understand the consequences of inaction and the benefits of various mitigation strategies (Rogelj et al., 2016).

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These models provided the scientific basis for setting emission reduction targets and developing national climate action plans.

Additionally, climate models have been used to inform regional policies and adaptation measures. For instance, models projecting increased frequency and intensity of extreme weather events have led to the implementation of improved flood management systems, infrastructure planning, and disaster preparedness strategies in vulnerable areas (Kundzewicz et al., 2014). By providing detailed and reliable projections, climate models enable policymakers to make informed decisions that enhance resilience and reduce risks associated with climate change.

4. ECONOMIC IMPLICATIONS

4.1. Analysis of the Economic Costs and Benefits of Climate Action

Climate change poses significant economic risks, but it also presents opportunities for economic benefits through proactive climate action. The economic costs of climate change are multifaceted, including direct damages from extreme weather events, health impacts, loss of productivity, and damage to infrastructure. According to the Stern Review, the overall costs and risks of climate change could be equivalent to losing at least 5% of global GDP each year, with the potential to rise to 20% or more if wider risks and impacts are considered (Stern, 2007).

Investing in climate mitigation and adaptation measures can reduce these costs significantly. For example, the transition to renewable energy sources not only reduces greenhouse gas emissions but also creates new industries and job opportunities. A study by the International Renewable Energy Agency (IRENA) found that doubling the share of renewables in the global energy mix by 2030 could increase global GDP by up to 1.1%, or approximately $1.3 trillion (IRENA, 2016). Furthermore, energy efficiency improvements can lead to substantial cost savings for businesses and households, enhancing economic productivity and competitiveness (McKinsey & Company, 2009).

Climate action also yields significant health benefits, which translate into economic gains. Reducing air pollution through cleaner energy sources can decrease respiratory and cardiovascular diseases, leading to lower healthcare costs and improved worker productivity (Nemet et al., 2010). Moreover, investing in climate-resilient infrastructure can prevent costly damages from extreme weather events, saving public and private expenditures in the long term (Hallegatte et al., 2013).

4.2. Importance of Proactive Measures in Preventing Future Economic Losses

Proactive measures to address climate change are crucial in preventing future economic losses. Delaying action increases the costs and risks associated with climate impacts. For instance, the National Climate Assessment reported that without significant reductions in greenhouse gas emissions, the United States alone could face economic damages of over $500 billion per year by the end of the century due to climate-related impacts on infrastructure, agriculture, and human health (USGCRP, 2018).

Investing in climate resilience and adaptation can mitigate these future costs. Coastal cities, for example, can invest in flood defenses and sustainable urban planning to protect against sea level rise and storm surges. The World Bank estimates that every dollar invested in climate-resilient infrastructure can yield up to $4 in benefits through avoided losses and economic gains (Hallegatte et al., 2019). Additionally, early investments in climate-smart agriculture can enhance food security and reduce the economic impacts of climate-related disruptions in food supply chains (Vermeulen et al., 2012).

Proactive measures also enhance economic stability by reducing the uncertainty and risks associated with climate change. By implementing robust climate policies and fostering innovation in green technologies, governments and businesses can create a more resilient and sustainable economic landscape. This not only protects against future economic shocks but also positions economies to thrive in a low-carbon future (IPCC, 2014).

In conclusion, the economic implications of climate action are profound. While the costs of inaction are high, investing in mitigation and adaptation measures offers substantial economic benefits. Proactive climate action is essential to prevent future economic losses, enhance resilience, and capitalize on the opportunities presented by a sustainable and low-carbon economy.

5. SECTORAL IMPACTS

5.1. Overview of Climate Change Effects on Key Sectors

Climate change affects various sectors differently, necessitating tailored solutions to mitigate its impacts and enhance resilience. Key sectors impacted by climate change include agriculture, water resources, health, the environment, and maritime transport.

- **Agriculture:** Climate change poses significant risks to agriculture, including altered precipitation patterns, increased frequency of extreme weather events, and the proliferation of pests and diseases. These changes threaten food security and agricultural productivity. Adaptive strategies, such as developing drought-resistant crop varieties, implementing sustainable farming practices, and utilizing precision agriculture technologies, are essential to enhance resilience and ensure food security (Lobell et al., 2011). For instance, drought-resistant crops can maintain yields under water-scarce conditions, helping farmers cope with changing climate conditions (Fedoroff et al., 2010).

- **Water Resources:** Water scarcity and management challenges are exacerbated by climate change. Changes in precipitation patterns and increased evaporation rates due to higher temperatures can lead to reduced water availability and quality. Solutions for addressing water scarcity include the adoption of efficient irrigation techniques, water recycling, and integrated water resource management. Technologies such as drip irrigation and rainwater harvesting can help optimize water use in agriculture and urban areas, ensuring sustainable water supply (Gleick, 2013).

- **Health:** Climate change impacts human health through the increased frequency and intensity of heatwaves, the spread of climate-sensitive diseases such as malaria and dengue fever, and the exacerbation of respiratory conditions due to poor air quality. Measures to combat these health impacts include strengthening healthcare systems, improving disease surveillance and early warning systems, and promoting public health interventions to reduce vulnerability. For example, vector control programs and community health education can reduce the incidence of climate-sensitive diseases (Haines et al., 2006).

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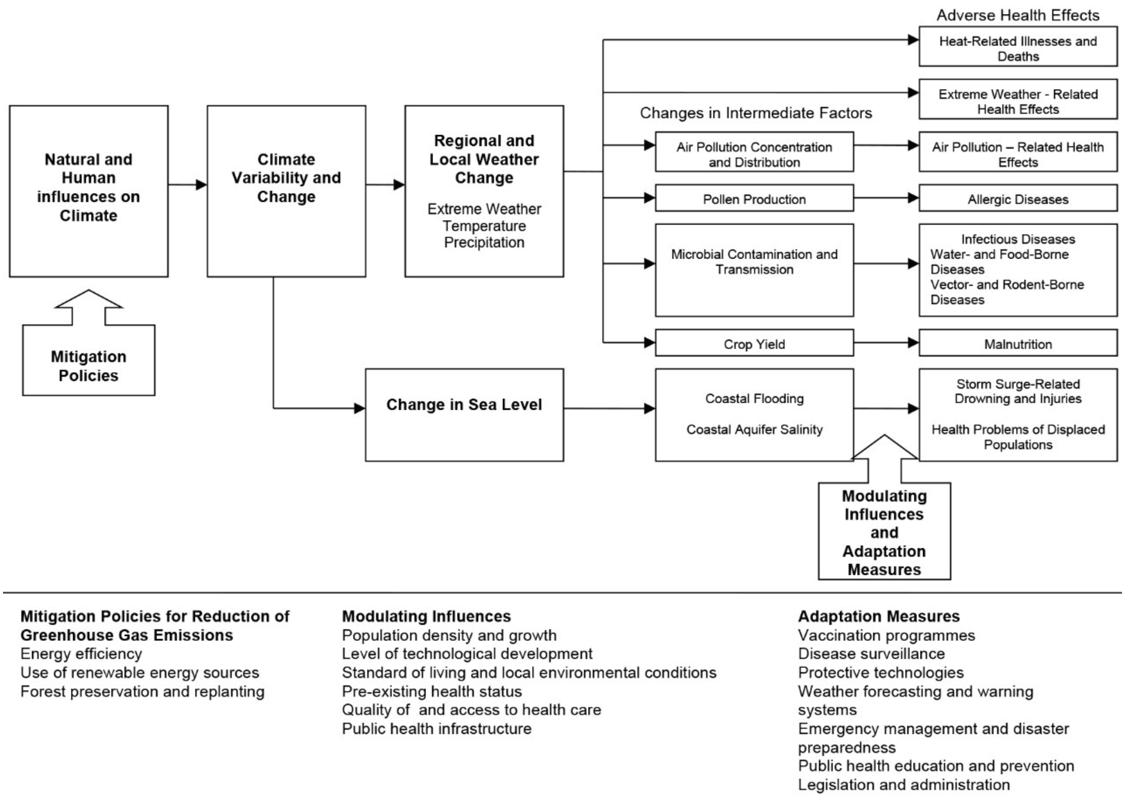

Fig. (2): Chart summarizing the health impacts of climate change, including the increased frequency of heatwaves and the spread of climate-sensitive diseases
Source: Haines et al. (2006)

- **Environment:** Biodiversity and ecosystems are under threat from climate change, which can lead to habitat loss, species extinction, and altered ecosystem functions. Conservation efforts, habitat restoration, and the protection of endangered species are vital to preserving ecological balance. Initiatives such as establishing protected areas, restoring degraded ecosystems, and promoting biodiversity-friendly agricultural practices are essential for maintaining ecosystem resilience (Thomas et al., 2004).

- **Maritime Transport:** The maritime transport sector is also significantly affected by climate change. Rising sea levels, increased frequency of severe storms, and changing ocean conditions pose risks to shipping routes, port infrastructure, and maritime safety. The International Maritime Organization (IMO) has emphasized the importance of adapting maritime transport to climate change through measures such as enhancing the resilience of port infrastructure, improving ship design and operations, and reducing greenhouse gas emissions from ships. Implementing these measures helps ensure the sustainability and safety of maritime transport (IMO, 2020).

6. CONCLUSION

6.1. Summary of the Importance of Interdisciplinary Research and International Cooperation

Addressing climate change is a global challenge that requires an integrated and coordinated approach. Interdisciplinary research is essential because it brings together diverse fields such as environmental science, economics, engineering, and social sciences to create comprehensive strategies for mitigation and adaptation. By leveraging the strengths and insights of different disciplines, we can develop more effective solutions that account for the complex nature of climate change and its wide-ranging impacts (Ostrom, 2009).

International cooperation is equally crucial. Climate change does not recognize borders, and its impacts are felt worldwide. Collaborative efforts among nations are necessary to share knowledge, resources, and technologies. Global agreements, such as the Paris Agreement, exemplify the importance of international cooperation in setting emission reduction targets and supporting developing countries in their climate actions (UNFCCC, 2015). These efforts help to ensure a unified response to a global problem, enhancing the effectiveness of climate policies and actions.

6.2. Call to Action for Continued Collaboration and Research to Address Climate Change

As we face the escalating impacts of climate change, there is an urgent need for continued collaboration and research. Governments, researchers, businesses, and civil society must work together to advance our understanding of climate dynamics, develop innovative technologies, and implement sustainable practices. Investments in climate research and the development of new mitigation and adaptation strategies are critical to addressing the challenges ahead (IPCC, 2014).

Moreover, there is a need for stronger policy frameworks that support climate action at all levels. Policymakers must prioritize climate resilience in infrastructure planning, promote renewable energy adoption, and incentivize sustainable practices across sectors. International organizations and agreements should continue to facilitate cooperation and provide platforms for sharing best practices and resources (Stern, 2007).

Public awareness and engagement are also vital. Educating communities about the impacts of climate change and the benefits of taking action can drive behavioral changes and support for climate policies. By fostering a culture of sustainability, we can build a global movement that prioritizes the health of our planet and future generations.

In conclusion, the fight against climate change requires a concerted effort from all sectors of society. Interdisciplinary research and international cooperation are key to developing effective solutions and ensuring a sustainable future. We must commit to ongoing collaboration, innovation, and action to mitigate the impacts of climate change and adapt to its inevitable consequences.

REFERENCES:

01. Benson, S. M., & Cole, D. R. (2008). CO2 Sequestration in Deep Sedimentary Formations. Elements, 4(5), 325-331.

02. Collins, W. D., et al. (2011). The Community Climate System Model Version 4. Journal of Climate, 24(19), 4973-4991.

03. Fedoroff, N. V., et al. (2010). Radically Rethinking Agriculture for the 21st Century. Science, 327(5967), 833-834.

04. Giorgi, F., et al. (2009). Regional Climate Change Information—Evaluation and Projections. Climate Change and Its Impacts: Risks and Inequalities, 2(4), 35-46.

05. Gleick, P. H. (2013). Water in Crisis: A Guide to the World's Fresh Water Resources. Oxford University Press.

06. Goulder, L. H., & Parry, I. W. H. (2008). Instrument Choice in Environmental Policy. Review of Environmental Economics and Policy, 2(2), 152-174.

07. Haines, A., Kovats, R. S., Campbell-Lendrum, D., & Corvalan, C. (2006). Climate Change and Human Health: Impacts, Vulnerability and Public Health. Public Health, 120(7), 585-596.

08. Hallegatte, S., et al. (2013). Economic Resilience: Definition and Measurement. World Bank Policy Research Working Paper No. 6852.

09. Hallegatte, S., Rentschler, J., & Rozenberg, J. (2019). Lifelines: The Resilient Infrastructure Opportunity. World Bank.

10. Hansen, J., et al. (2010). Global Surface Temperature Change. Reviews of Geophysics, 48(4), RG4004.

11. Hilborn, R. (2007). Managing Fisheries is Managing People: What has been Learned? Fish and Fisheries, 8(4), 285-296.

12. IMO. (2020). Fourth IMO GHG Study 2020. International Maritime Organization.

http://dx.doi.org/10.21622/MACI.2024.01.1.907

13. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

14. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

15. IPCC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

16. IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

17. IRENA. (2016). Renewable Energy Benefits: Measuring the Economics.

18. Kundzewicz, Z. W., et al. (2014). Flood Risk and Climate Change: Global and Regional Perspectives. Hydrological Sciences Journal, 59(1), 1-28.

19. Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate Trends and Global Crop Production Since 1980. Science, 333(6042), 616-620.

20. McKinsey & Company. (2009). Unlocking Energy Efficiency in the U.S. Economy.

21. Moser, S. C., & Dilling, L. (2007). Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change. Cambridge University Press.

22. Nemet, G. F., Holloway, T., & Meier, P. (2010). Implications of Incorporating Air-Quality Co-Benefits into Climate Change Policymaking. Environmental Research Letters, 5(1), 014007.

23. Nisbet, M. C. (2009). Communicating Climate Change: Why Frames Matter for Public Engagement. Environment: Science and Policy for Sustainable Development, 51(2), 12-23.

24. Ostrom, E. (2009). A Polycentric Approach for Coping with Climate Change. Background Paper to the 2010 World Development Report.

25. Ostrom, E. (2009). A Polycentric Approach for Coping with Climate Change. Background Paper to the 2010 World Development Report.

26. Parmesan, C., Duarte, C. M., Poloczanska, E., Richardson, A. J., & Singer, M. C. (2013). Overstretching Attribution. Nature Climate Change, 3(9), 759-761.

27. Pikitch, E. K., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., ... & Sainsbury, K. J. (2004). Ecosystem-Based Fishery Management. Science, 305(5682), 346-347.

28. Randall, D. A., et al. (2007). Climate Models and Their Evaluation. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

29. Rogelj, J., et al. (2016). Paris Agreement Climate Proposals Need a Boost to Keep Warming Well Below 2°C. Nature, 534(7609), 631-639.

30. Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge University Press.

31. Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge University Press.

32. Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge University Press.

33. Thomas, C. D., et al. (2004). Extinction Risk from Climate Change. Nature, 427(6970), 145-148.

34. Thorne, P. W., et al. (2011). A Quantitative Assessment of Uncertainty in Global Temperature Projections. Environmental Research Letters, 6(4), 044005.

35. UNFCCC. (2015). Adoption of the Paris Agreement. United Nations Framework Convention on Climate Change.

36. UNFCCC. (2020). Climate Change: Impacts, Vulnerabilities, and Adaptation in Developing Countries. United Nations Framework Convention on Climate Change.

37. USGCRP. (2018). Fourth National Climate Assessment. U.S. Global Change Research Program.

38. Vermeulen, S. J., et al. (2012). Climate Change and Food Systems. Annual Review of Environment and Resources, 37, 195-222.

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CIVIC UNIVERSITY MODEL AS LIVING LAB - POTENTIAL AND CHALLENGES

FOR THE OUTPUT "DESIGNING SKILLS AND ROLE FOR "CIVIC UNIVERSITIES"" OF THE ENI CBC MED "MED-QUAD" PROJECT

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ABSTRACT:

This article explores the Civic University model's potential as a Living Lab, highlighting its capacity to integrate academia into the societal fabric and promote sustainable development. It examines the concept of Civic Universities, entities that prioritize positive civic impact through engagement with local communities. The study delves into the Living Lab approach, characterized by user-centered, open innovation ecosystems where stakeholders from public, private, and academic sectors collaborate in real-world settings. Further, it discusses the Quadruple and Quintuple Helix frameworks, illustrating how these models facilitate multi-stakeholder collaboration to foster innovation and address complex challenges. The article also connects these concepts with the Sustainable Development Goals (SDGs), emphasizing the role of Civic Universities in achieving these global objectives. Through the lens of the ENI CBC MED 'MED-QUAD' project, the article exemplifies how the integration of these frameworks can lead to impactful societal and economic development, particularly in the Mediterranean region. The findings underscore the significance of Civic Universities as Living Labs in cultivating an innovative, sustainable, and inclusive future.

KEY-WORDS: Sustainable Development Goals (SDGs), Quadruple Helix, Quintuple Helix, Innovation Ecosystem, Community Engagement, Public-Private Partnerships, Stakeholder Collaboration, Urban Living Labs, Sustainability, Educational Integration, Research for Public Good, Place-based Education, MED-QUAD.

ENI CBCMED Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

MED-QUAD

1. INTRODUCTION

To construct a dynamic model inside the university that emphasizes its position within society and expedites sustainable development goals, this article discusses the civic university and how it can benefit from emerging concepts like the Living Lab and quadruple/quintuple helix framework.

> "While universities are vital to their places, they also need the active support of their communities in these turbulent and challenging times."
>
> *Lord Kerslake, (FAcSS), awarded the Fellowship of the Academy of Social Sciences (FAcSS), granted by the Academy of Social Sciences to leading academics, policymakers, and practitioners of the social sciences.*

The Civic University (CU)

A university can be regarded as a ***civic university*** if its purpose, and the strategy that supports it includes making a positive civic impact. On the other hand, universities that only undertake valuable civic activity can be regarded as *civically engaged universities.* (1)

A civic university is a university that recognizes and prioritizes its role in serving and engaging with its local community. This involves working with community members, organizations, and government agencies to address local challenges and create social, cultural, and economic benefits for the community. This can be in the form of ***Community partnerships***, where the university works with local organizations and community members to create programs and initiatives that address local challenges and meet community needs through partnering with local government agencies, non-profit organizations, and businesses to create collaborative solutions. And in the form of ***Service Learning*** by incorporating community service and engaging into their academic programs to give students the opportunity to apply their skills and knowledge to real-world challenges in the local community. The civic university shall be involved in ***Research for the public good*** that addresses local challenges and has the potential to create social, cultural, and economic benefits for the community, which involves partnering with community members and organizations to identify research priorities and co-create solutions. One of the vital features of the civic university is ***Place-based education***, where the universities use their local community as a learning laboratory or as a *Living Lab (LL),* creating opportunities for students to explore and learn from their local environment, culture, and history.

> "If you want to build a great city, create a great university and wait 200 years."
>
> *Senator Daniel Patrick Moynihan*

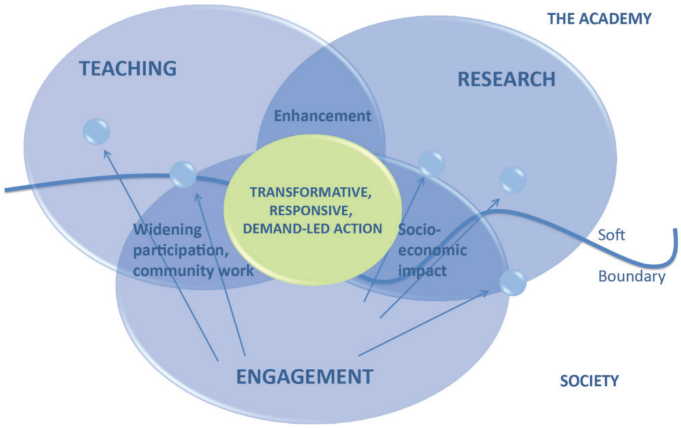

Fig. (1): A civic university
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The University as a Living Lab

William J. Mitchell, Kent Larson, and Alex (Sandy) Pentland at the Massachusetts Institute of Technology are credited with first exploring the concept of a Living Laboratory (2). They are "User-centered, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" as defined by the European Network of Living Labs (ENoLL). Westerlund and Leminen (3) described Living Labs (LLs) as physical regions or virtual realities where stakeholders form public-private-people partnerships (4Ps) of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts.

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Fig. (2): The living lab stakeholders
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Living labs are an open innovation ecosystem that involves users, academics, and industry in creating innovative outcomes to match the scientific potential with the real needs on the ground. Either virtual or physical spaces, the Living Labs (LLs) enable the collaboration of multiple stakeholders in a real-life context to co-create solutions, often in urban areas (4).

The basic idea of student engagement for sustainability reinforcements at a university is to offer students the chance to participate in sustainability activities outside the classroom, gain real-world experiences, and learn how to work with various stakeholders from the industry. The campus can serve as a living lab that connects student engagement through education with sustainability outcomes on an urban campus.

The Quadruple and Quintuple (Q2H) Helix Framework

QH framework (Figs 3 & 4) is based on models by Carayannis and Campbell (5) and Galvao (6). The Quadruple helix model emphasizes the importance of collaboration between universities, policymakers, civil society, and industry. The Quintuple Helix model builds on this by including the overall ecosystem in the collaboration. Collaboration between stakeholders is an essential factor in overcoming obstacles and generating innovative solutions through research and development (7). The helix models of innovation highlight the important role universities play in promoting innovation in our knowledge-based society (8).

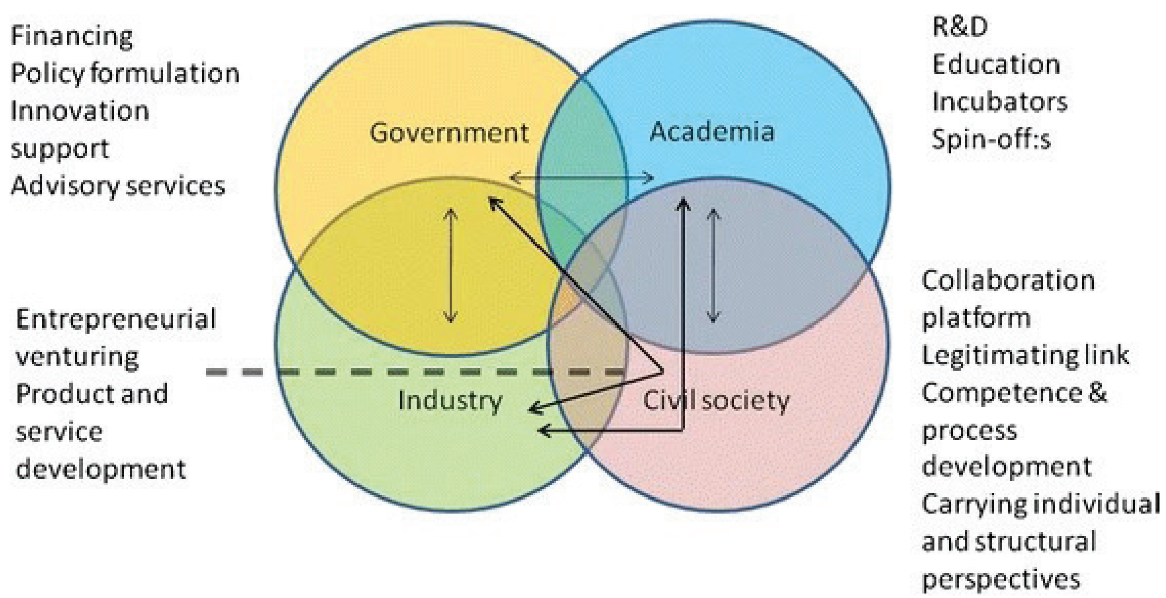

Fig. (3): Quadruple Helix framework
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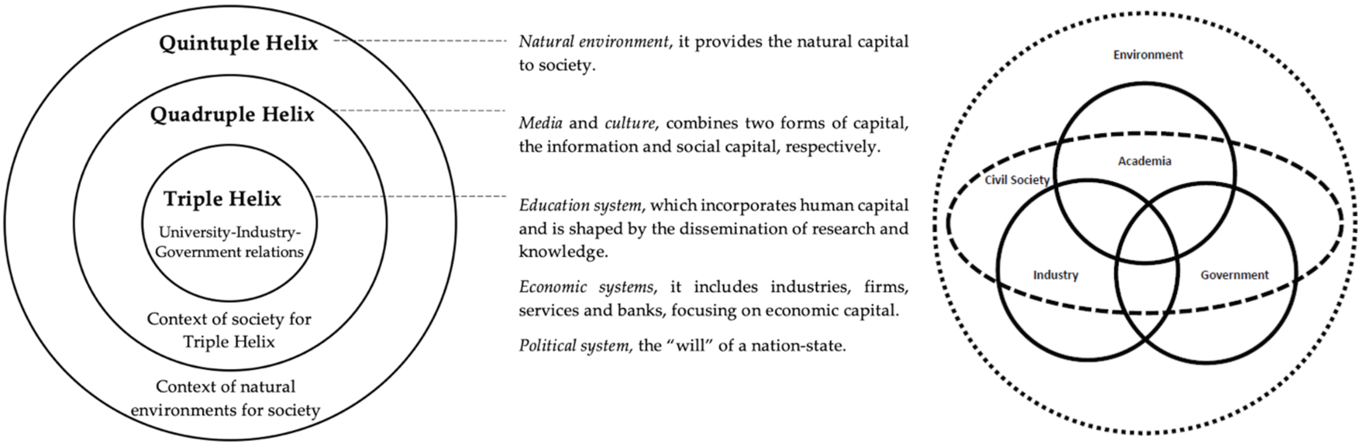

Fig. (4): Quintuple Helix Innovation Model for the European Union Defense Industry—An Empirical Research
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2. THE CIVIC UNIV. AS A LIVING LAB UTILIZING THE QUADRUPLE/QUINTUPLE HELIX (Q2H) FRAMEWORK

The concept of using universities as Living Labs (LLs) using the quadruple/quintuple helix (Q2H) framework is an innovative approach to driving sustainable development and promoting collaboration between various stakeholders.

The Q2H framework involves the collaboration of key stakeholders, namely, academia, industry, government, civil society and the environment. This approach promotes the exchange of knowledge, skills, and resources between these stakeholders to drive innovation and development.

In the context of using universities as LLs, the Q2H framework involves leveraging the resources, expertise, and innovation of universities to address real-world problems in collaboration with industry, government, civil society, and the environment. This approach facilitates the co-creation of knowledge and solutions that are relevant and impactful to society.

By using universities as LLs, students, faculty, and researchers can work with external stakeholders to co-create solutions to real-world problems, and test and validate these solutions in a real-world context. This approach not only promotes innovation but also provides students with practical learning opportunities and industry experience.

Overall, the concept of using universities as LLs using the quadruple helQ2H framework has the potential to drive sustainable development and create a collaborative innovation ecosystem that benefits all stakeholders involved.

3. INTEGRATING THE Q2H FRAMEWORK AND THE SDGS

The Agenda 2030 for Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, is a global initiative aimed at addressing pressing global challenges, including poverty, inequality, environmental degradation, and more. Its primary purpose is to promote sustainable development and improve the well-being of people and the planet by 2030.

The UN report (9) explains the 17 Sustainable Development Goals (SDGs) and the 169 associated targets. These goals cover a wide range of social, economic, and environmental issues and provide a comprehensive framework for action at the global, national, and local levels. It emphasizes the importance of multi-stakeholder engagement, including governments, civil society, businesses, and academia, to work together towards achieving the SDGs.

The Agenda 2030 for SDGs and the Q2H Model are related in the sense that both advocate for multi-stakeholder collaboration and emphasize the importance of various sectors working together to achieve common goals. The Q2H Model can provide a conceptual framework for understanding how different actors, including government, academia, industry, civil society, and media, can collaborate to implement and advance the SDGs outlined in

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Agenda 2030 (10).

In practical terms, the Q2H Model can be used as a guiding framework for designing and implementing initiatives that align with the SDGs. It encourages a holistic approach to sustainable development by considering the diverse perspectives and contributions of various stakeholders. Thus, these two concepts can complement each other in efforts to address complex global challenges and promote sustainable development. The Agenda 2030 for Sustainable Development Goals (SDGs) and the Q2H Model are both frameworks designed to address complex societal challenges and promote sustainable development, but they have different focuses and purposes.

Both the Helix framework and the SDGs are powerful instruments for organizing, educating, and integrating future societies.

- Helix models provide abstract, conceptual, and evolutionary frames based on cross-fertilized knowledge and innovation from stakeholders like universities, industry, government, society, and the environment.

- The UN SDGs formulate practical, hands-on, and fine-grained targets in multiple realms (social, educational, economic, environmental, and political) with the goal of implementing more sustainable practices by 2030.

4. CIVIC UNIVERSITY (CU) ACTING AS LIVING LABS (LLS) WITHIN THE Q2H FRAMEWORK

Potential for CU as LLs using QH Framework

The potential for a civic university as a living lab using the Q2 helix model is significant. By engaging with the community and bringing together multiple stakeholders, a civic university can create a dynamic innovation ecosystem that fosters economic and social development. The Q2 helix model provides a framework for collaboration between academia, industry, government, civil society, and the environment, which can result in more innovative and effective solutions to complex problems.

A civic university can act as a hub for this collaboration, bringing together stakeholders from different sectors and facilitating dialogue, cooperation, and co-creation. By working together, stakeholders can identify common goals and develop solutions that are tailored to the needs of the community.

In addition to the benefits for the community, the engagement of a civic university in a living lab using the Q2 helix model can also benefit the institution itself. It can provide opportunities for interdisciplinary research, student engagement, and networking, and can enhance the university's reputation and profile.

Here are some potential benefits:

1. **Addressing Real-world Challenges:** A civic university can use the living lab approach to identify and address real-world challenges faced by the community. This approach ensures that research and innovation are relevant and useful to society.

2. **Engaging Stakeholders:** The Q2 helix model emphasizes the importance of engagement and collaboration among academia, government, industry, civil society, and the environment. A living lab approach can facilitate stakeholder engagement and ensure that all parties are involved in the innovation process.

3. **Fostering Innovation:** A living lab approach can facilitate the co-creation of innovative solutions by bringing together different perspectives, resources, and expertise. The Q2 helix model ensures that innovation is not limited to academia or industry but is a collaborative effort.

4. **Enhancing Education:** A civic university can use the living lab approach to enhance the education of its students by providing them with opportunities to work on real-world projects and collaborate with stakeholders from different sectors.

5. **Economic Development:** A civic university can contribute to the economic development of its region by promoting innovation and entrepreneurship. The living lab approach can facilitate the creation of new businesses and products that address local needs and create jobs.

A civic university as a living lab using the Q2 helix model has the potential to create a collaborative and innovative ecosystem that addresses real-world challenges, engages stakeholders, fosters innovation, enhances education, and contributes to economic development.

Fig. (5): UN 17 Sustainable Development Goals and dominant Helix properties
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Challenges facing CU acting as LLs within the 2H Framework:

A civic university as a living lab, using the Q2 helix model, faces several challenges. Here are some of them:

1. **Collaboration:** collaboration between the stakeholders can be challenging due to differences in priorities, goals, and communication styles. Building and maintaining strong relationships among the stakeholders is essential to overcome these challenges.

2. **Funding:** Implementing a living lab requires resources, including funding. Universities may struggle to secure funding for their living lab initiatives, especially if they do not have strong partnerships with industry and government.

3. **Ethics and Governance:** Living lab initiatives involve human participants, and thus ethical considerations must be considered. Universities must establish ethical guidelines for their living labs and ensure that they adhere to them. In addition, the governance structure of the living lab must be established, and the stakeholders must agree on how decisions will be made.

4. **Scalability:** Living labs are often focused on a specific geographic area or community. To be successful, the living lab must demonstrate that its results can be scaled up to a broader context. The living lab must also show that it can be replicated in other contexts.

5. **Data Management:** Living labs generate vast amounts of data, and managing this data can be challenging. Universities must establish protocols for data collection, storage, and sharing. In addition, they must ensure that the data is secure and that participants' privacy is protected.

6. **Measuring Success:** Living labs are designed to produce tangible outcomes, but measuring success can be challenging. Universities must establish metrics to measure the success of their living labs and ensure that these metrics are aligned with the goals of the living lab.

Implementing a living lab using the quadruple helix model is a complex undertaking. Universities must navigate a range of challenges to ensure that their living lab initiatives are successful.

5. THE MED-QUAD PROJECT

The MED-QUAD project applies the Quadruple Helix (QH) approach to support innovation and sustainable local development among partner countries: Italy, Greece, Egypt, Tunisia, Palestine, and Jordan. The project's partners applied actions to support innovation and sustainable local development based on the QH. Actions were based on the awareness that government, businesses, academia, and citizens will be able to align goals, amplify resources, and accelerate progress by joining forces.

MED-QUAD addressed challenges in project partners' countries by creating the right environment where universities, SMEs, and governments cooperate and promote the innovation of processes and products. The QH approach is applied to the planned cross-border Living Labs focused on two crucial issues:

1. **Smart Water Use Applications – SWUAP:** quality traceability for drinking water, quality assessment of water for irrigation, traceability of vegetables from fields to shops, smart packaging and

2. **Applied Research for Cultural Heritage Exploitation-ARCHEO:** Augmented reality applied to archaeology, architecture, and art. Mixed Realities and their concept of cyber-real space interplay. A full appreciation of cultural heritage sites. Virtual and augmented reality technologies that will provide historically accurate reconstructions and relevant contextual information.

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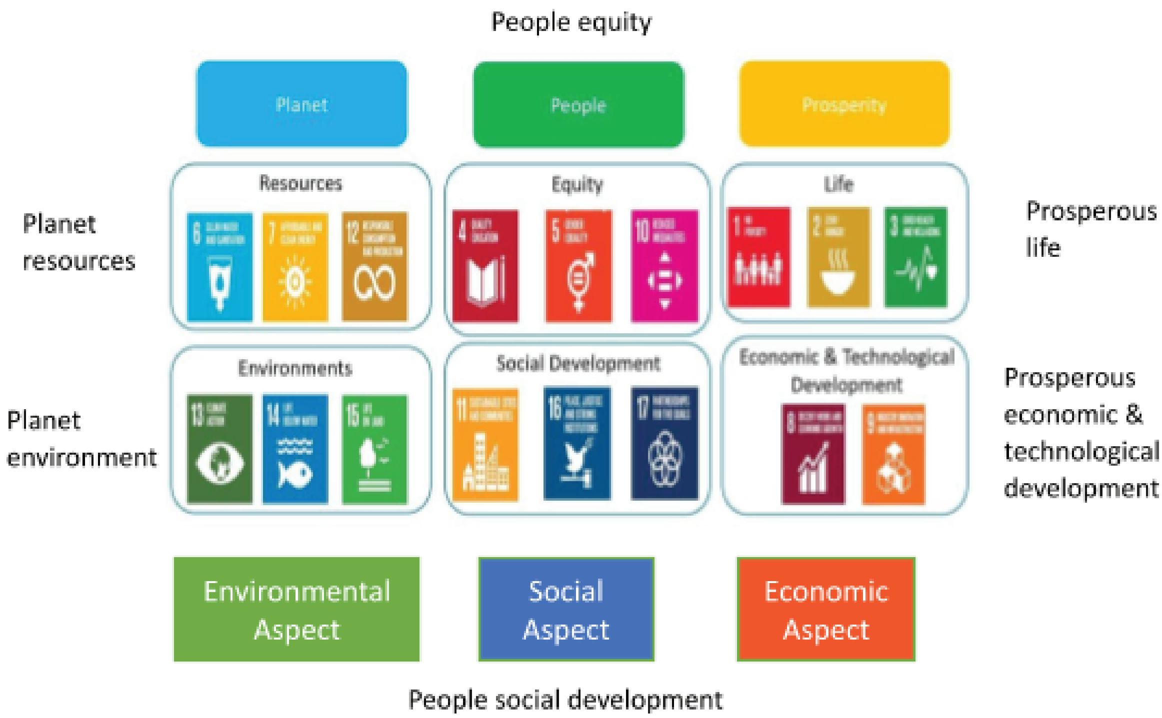
Outcomes of some partners in the Arab Region

- The Arab Academy for Science, Technology, and Maritime Transport "AASTMT", Egypt:

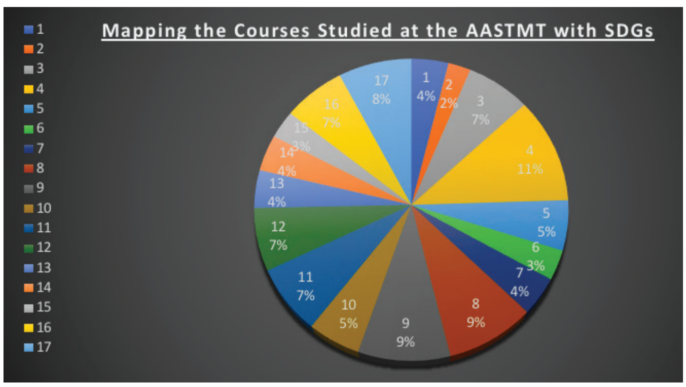
Within the Med- Quad project funded by the EU Horizon, AASTMT applied the CU model acting as LL and using the Q2H Framework. AASTMT gathered forces to become a sustainable campus. They established a community of staff, employees, and students spearheaded to advance the SDGs within the AASTMT campuses. A special link "Sustainable AASTMT" was created to include all the policies, goals, initiatives, news, etc., all concerning sustainable development and the SDGs implemented within the campuses. A committee of officers was assigned the responsibility of advancing the SDGs with an officer for each SDG. The Committee management gathered the SDGs into six clusters according to the related themes within the AASTMT community.



AASTMT insights towards SDGs

Towards SDG4: Since 2021, the AASTMT has developed mapping matrices that indicate the direct relationship between educational program courses and SDGs, to increase awareness about SDGs and enhance the participation of different stakeholders, such as students, lecturers, employees, and community, in the achievement of SDGs. Each program in AASTMT has a matrix that shows a partial or complete addressing of a certain SDG or group of SDGs within the teaching courses.

The plan is to generalize the evaluation of SDGs in most of the courses within the AAST In order to measure the achievement of SDGs within the teaching course. It has gone further in 2022 to measure the achievement of SDGs within the teaching course in evaluating the understanding of students the SDG concept and practicing activities that support their achievement. The plan of SDGs workforce is to generalize the evaluation of SDGs in most of courses within the AAST starting from September 2023.



- Palestine Polytechnic Univ.:

Within the framework of MED-QUAD project, the ARCHEO Virtual Reality Laboratory team at Palestine Polytechnic developed a model to preserve and develop the cultural heritage of historical sites in the city of Hebron using 3D scanning techniques and virtual reality software. The model will be adopted by the Ministry of Tourism and Cultural Heritage within the Ministry's plan to develop the Palestinian Virtual Museum.

The team at the Water Quality Laboratory SWUAP developed a process to remotely monitor water quality using the Internet of Things (IoT). They cooperated with the Water Department in Hebron Municipality to install and operate the device to monitor changes in the quality of the water distributed in the city, where the measurements are sent via the Internet to the laboratory in the Biotechnology Center at the university with the aim of making a model that can be applied to ensure public health.

The Palestine Polytechnic University in cooperation with a relative EU project established a network of 5 agro-technological centers in 5 Universities in Jordan and Palestine to develop practical and innovative Vocational Education and Training (VET) courses equipping students with new skills, not addressed in traditional curricula. The AgroTech centers will promote cooperation between companies and VET institutions as well as create links between all stakeholders of the agri-food value chain.

- Al-Balqa Applied University - Jordan:

The Smart Water Use Applications (SWUAP) lab at Al-Balqa Applied University joined forces with industry to enhance water management in the industrial sector. Their collaboration will implement advanced water solutions to ensure top-notch water quality and safety. This partnership addresses challenges, boosts food safety, and drives innovation in industrial water treatment, benefiting the environment and businesses alike.

6. ACKNOWLEDGMENT

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REFERENCES:

01. Commission UFCU. Truly Civic: Strengthening the connection between universities and their places. ; 2019.

02. WIKIPEDIA.. [cited 2023 August 14. Available from: https://en.wikipedia.org/wiki/Living_lab.

03. Westerlund M, Leminen. Managing the Challenges of Becoming an Open Innovation Company: Experiences from Living Labs. Technology Innovation Management Review. 2011 October;: 19-25.

04. Iyer-Raniga U, Mori Junior. Urban Living Labs: Explorations in a University Setting. Quality Education. 2020 January;: 1-12.

05. Carayannis G, Campbell. 'Mode 3' and 'Quadruple Helix': toward a 21st-century fractal innovation ecosystem. International Journal of Technology Management. 2009;: 201-234.

06. Galvao , Mascarenhas C, Marques , Ferreira , Ratten V. Triple helix and its evolution: a systematic literature review. Journal of Science and Technology Policy Management.

2019;: 812-833.

07. Al-Ali A, Stephens M, Ajayan S. Integration of the Quintuple Helix innovation Model into the Higher Education Sector: The case of Mohammed bin Rashid School of Government. International Journal of Innovation, Creativity and Change. 2020;: 959-972.

08. Zakaria H, Kamarudin D, Fauzi A, Wider. Mapping the helix model of innovation influence on education: A bibliometric review. Frontiers in Education. 2023.

09. Goddard J. The Role of Civic Universities in the Coronavirus Crisis and Beyond. 2020. City-REDI Blog, University of Birmingham.

10. Steen, Kris; van Bueren, Ellen . Urban Living Labs: A Living Lab Way of Working. 1st ed. Amsterdam: AMS Institute; 2017.

11. Lindberg , Lindgren , Packendorff. Quadruple Helix as a Way to Bridge the Gender Gap in Entrepreneurship: The Case of an Innovation System Project in the Baltic Sea Region. Journal of the Knowledge Economy. 2014 February: p. 94-113.

12. Reis J, Rosado , Ribeiro D, Melão. Quintuple Helix Innovation Model for the European Union Defense Industry—An Empirical Research. Sustainability. 2022.

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IS COLD IRONING (ONSHORE POWER SUPPLY, OR ALTERNATIVE MARITIME POWER, OR SHORE-TO-SHIP POWER) A VIABLE SOLUTION FOR REDUCING GREENHOUSE GAS EMISSIONS IN PORTS? EU / GREEK PORTS PERSPECTIVE

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ABSTRACT:

Adaptation to climate change has led Institutional bodies to work relentlessly to find solutions to this progressing problem. European Union has been diligently formulating a comprehensive institutional framework aimed at addressing maritime transport's environmental impact and fostering sustainable practices. Maritime transport, responsible for approximately 75% of the Union's external trade and 31% of its internal trade by volume, plays a pivotal role in the economy of the Union. However, it also accounts for a significant portion of carbon dioxide (CO2) emissions within the EU, contributing around 11% of all EU CO2 emissions from transport and 3 to 4% of total CO2 emissions in the EU.

In response to the pressing need to curb emissions, Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') set a clear objective for the net reduction of greenhouse gas (GHG) emissions by at least 55% compared to 1990 levels by 2030. Moreover, this regulation places the Union on a trajectory towards achieving net zero GHG emissions by 2050. As part of this commitment, complementary policies have been introduced to expedite the adoption of sustainably produced renewable and low-carbon fuels in the maritime transport sector, all while respecting technological neutrality.

Regulation (EU) 2023/1804 requires the port to be able to provide shore-side electricity supply for at least 90% of container vessels over 5,000 GT, ro-ro passenger ships and high-speed passenger craft over 5,000 gt, and passenger ships over 5,000 gt, provided the annual average number of ships in each of these categories exceeds 100, 40 and 25 respectively. However, the lack of a common methodology for setting targets and adopting measures in national policies led to significant differences in the levels of ambition between Member States which was perceived as a hindrance to the establishment of a comprehensive network of alternative fuel infrastructure.

The paper examines the most important obstacles and towards EU legislative framework implementation and techno-economic challenges.

KEY-WORDS: Maritime Decarbonization, Cold Ironing, Onshore Power Supply, Climate Adaptation in Shipping and Ports, Sustainable Development.

1. INTRODUCTION

European environmental legislation has clearly committed the EU to becoming climate-neutral, achieving net-zero greenhouse gas emissions by 2050. The European Green Deal of 2019 is based on four pillars covering issues related to the implementation of the appropriate regulatory framework, financing specialized measures and policies, necessary skills adaptation for the implementation of innovative environmental actions, and the liberalization of global trade to enhance the EU's bilateral trade relations with its partners and avoid unfair competition practices.

In 2021, the European Parliament adopted the European Climate Law, which sets the achievable target of reducing greenhouse gas emissions by 55% by 2030 (compared to 1990 levels) and designates 2050 as the milestone date by which the EU will become entirely climate neutral. The implementation of these targets is institutionally reinforced by the adoption of the policy package known as "Fit for 55."

All productive sectors are included in the measures specified in the "Fit for 55" package, including shipping, which is most directly impacted by the EU Emission Trading System (ETS) as it came into effect on May 16, 2023. Additionally, the shipping sector is affected by the FuelEU Maritime Regulation, which is awaiting finalization and approval by the European Parliament and the European Council, the Energy Taxation Directive, the Alternative Fuels Infrastructure Regulation effective from July 13, 2023, and the Renewable Energy Directive.

As can be understood, the regulatory work at the EU level is continuous, and the institutional bodies of each member state, as well as representatives of sectoral interests within the EU, are working tirelessly to have their views, which reflect their specific interests, adopted institutionally and become EU legislation.

At the same time, the strict timelines set with the milestone years 2030 and 2050 intensify the efforts of entities (both private and public) to comply within these limits, even without waiting for the details and final adaptation requirements.

The shipping industry is in constant pursuit of the prevailing trends in the energy and maritime fuels sector, while the port industry is preparing the zero-emission ports of tomorrow, which now seem very close.

2. THE INSTITUTIONAL FRAMEWORK

The prevailing view for reducing greenhouse gas emissions is reported to be the creation of infrastructure for providing electric power to approaching ships, which, according to the most recent legislation (AFIR, 2023), must be supplied at least at ports belonging to the Trans-European Transport Network (TEN-T), with priority given to seagoing container ships and seagoing passenger ships, as these categories are recognized as the most energy-demanding and the most polluting.

The same legislation mentions that ports should be cautious about the underperformance of attempted capital investments. Special attention is also given to island areas that are not connected to the central power grid and rely exclusively on non-renewable sources, specifically conventional fossil hydrocarbons, for electricity production.

The finalization of technical requirements for installing power supply systems on commercial ships is expected in the coming months. Many ports, mainly in mainland Europe, have already installed such systems alongside networks for providing alternative maritime fuels, such as natural gas and hydrogen.

3. CONSTRAINTS AND CHALLENGES FOR THE GREEK PORT SYSTEM

In Greece, the ports within the core network of the Trans-European Transport Network with the highest traffic of container ships and cruise ships have initiated studies for the installation of Onshore Power Supply (OPS) systems. Piraeus, Heraklion in Crete, and Igoumenitsa have completed the study phase and are now in the development stage of the related infrastructure.

So, what are the biggest obstacles to developing such systems, and how economically feasible is this transition for port authorities and shipowners?

Obstacles such as infrastructure financing, delays in finalizing technological guidelines, and the issue of continuous power supply are some of the most significant challenges in the effort to decarbonize the port and maritime industry. Specifically:

- **Port Infrastructure Cost:** The infrastructure cost, including studies and permits, is in the tens of millions, depending on the installed capacity and the prospect of serving primarily cruise ships, which are the most demanding in electrical energy during berthing. Assuming the minimum power requirement per ship is approximately 5-7 MW, then planning to serve two or three ships simultaneously raises the installed power requirement to at least 15 MW, with capital expenditure exceeding 25 million euros, depending on the complexity and technical work requirements within the port area and the cost of creating a substation. Such an investment cannot be supported based on the financial statements of most Greek ports.

- **Cost of Ancillary Works:** This cost pertains to the necessary infrastructure for transmitting electrical energy to the port installation and is considered significant.

- **Capital Investment in Ships:** The requirement for ports to comply with EU environmental legislation makes the corresponding adaptation of ships mandatory, with the cost per installation amounting to hundreds of thousands of euros.

- **Operational Cost – Charge per kWh:** This concerns the cost that each electrically powered ship will have to pay to the electricity provider. It is clear that this cost must be comparable to the opportunity cost created by forgoing the use of the ship's generators, which in turn is influenced by the international prices of MGO (marine gas oil).

4. CONCLUSION

Based on realistic figures regarding the cost of infrastructure and current electricity selling prices, and considering the marine gasoil prices in August 2023, we conclude that:

- The EU (as a whole) still lacks practical results compared to its rapidly evolving environmental regulatory framework.

- Issues of internal competition between countries and infrastructures that may, for various reasons, fulfill their environmental commitments at different times have not been sufficiently studied.

- The cost of studies and infrastructure cannot be undertaken by all ports, many of which serve specific and seasonal needs, without substantial subsidies approaching 80%.

- Ports are evolving into hubs for providing electricity, either by investing in energy production themselves or by entering into agreements with existing energy providers.

- The selling price of electricity is a key factor in the project's success, without compromising the quality of service in terms of frequency and regularity.

- The equivalent selling price of electricity compared to marine gasoil (MGO equivalent) is currently around €0.19/kWh, significantly lower than the selling price of electricity (€0.55/kWh), thus creating a significant "financial gap" for the shipowner **(Figure 1)**. With an electricity selling price of €0.55/kWh, the equivalent price of MGO is €2,558.1/tonne **(Figure 1)**.

- The annual benefit from the reduction of greenhouse gas emissions, especially CO2, must be considered, given that CO2 is now a traded commodity (the current price of 1 tonne of CO2 on 11/08/2023 was $92.77) **(Figure 2)**.

- Quantifying the environmental benefit and distributing it among all stakeholders should serve as an incentive and help mitigate the impact of the capital costs of environmental investments.

To sum up, decarbonizing the maritime industry is a complex issue with multiple components and consequences that can affect competition and the viability of critical activities. Therefore, the environmental approach requires a thorough consideration of cost-benefit elements with the ultimate goal of maintaining competitiveness and ensuring that environmental adaptation does not become a destabilizing factor.

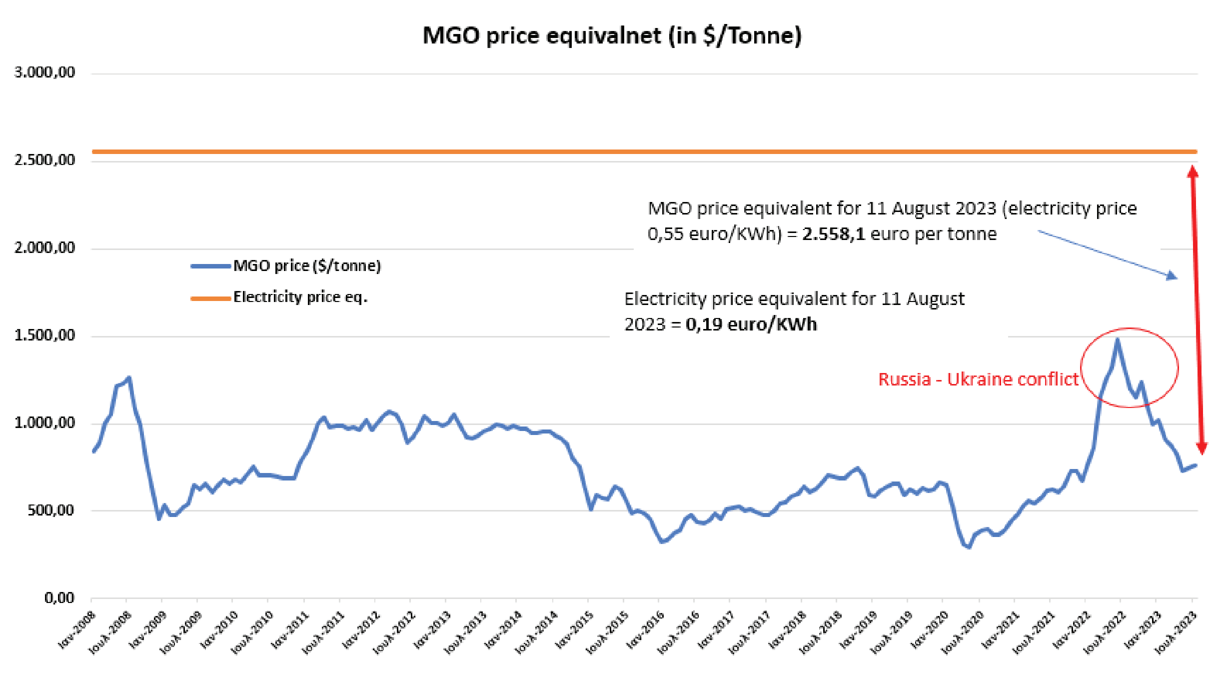

Fig. (1): Calculation of Equivalent MGO Price for the Same Period of Electricity Consumption in the Port
Source: data elaborated by Authors (database Clarksons, August 2023)

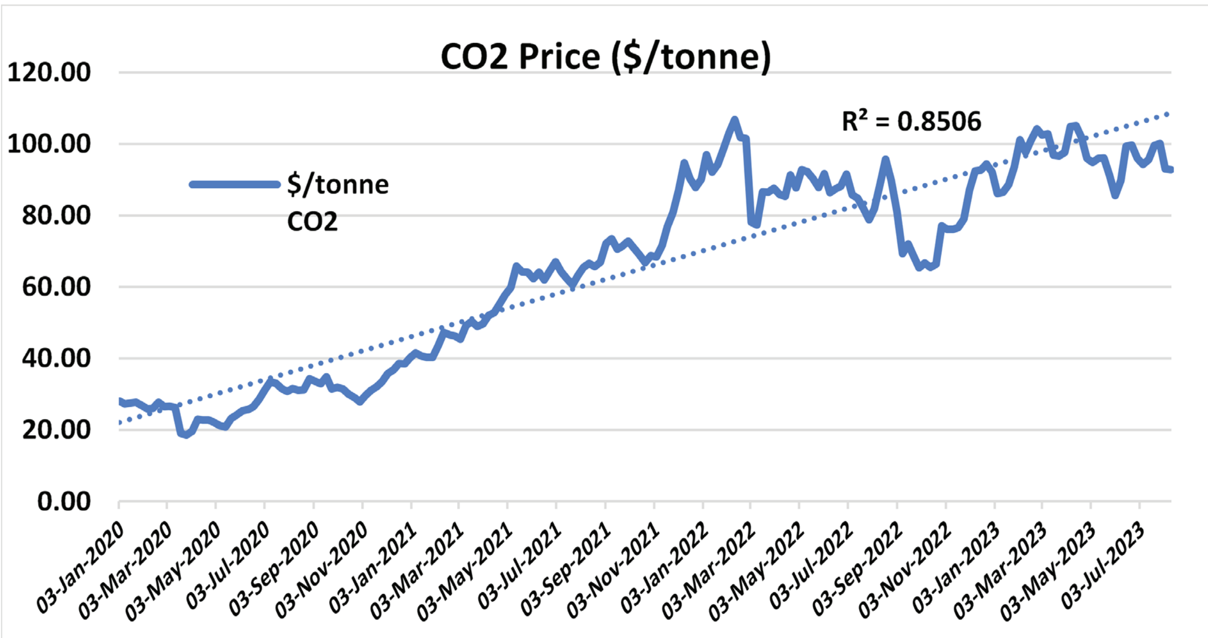

Fig. (2): CO2 Price per ton (August 2023) and Long-term Trend
Source: data elaborated by Authors (database Clarksons, August 2023)

http://dx.doi.org/10.21622/MACI.2024.01.1.915

REFERENCES:

01. Abdaoui, A. (2021) 'Feasibility study of cold ironing from renewable sources in the Nordic region: case study : Port of Kapellskär in Stockholm'. *World Maritime University Dissertations*. 1665. https://commons.wmu.se/all_dissertations/1665

02. Bernacchi, R. (2017) 'From Shore-to-ship to smart ports: Balancing demand and supply and optimizing capital expenditures. White paper'. Available at: https://search.abb.com/library/Download.aspx?DocumentID=9AKK1070 45A4337& LanguageCode = en&DocumentPartId = &Action=Launch

03. Coppola, T., Fantauzzi, M., Miranda, S. and Quaranta, F. (2016) 'Cost/benefit analysis of alternative systems for feeding electric energy to ships in port from ashore'. *2016 AEIT International Annual Conference (AEIT),* Capri, Italy, 1-7, doi: 10.23919/AEIT.2016.7892782.

04. European Sea Ports Organisation (ESPO) (2021) 'ESPO Green Guide 2021. A Manual for European Ports Towards a Green Future'. Available at: https://www.espo.be/media/ESPO%20Green%20Guide%202021%20-%20FINAL.pdf

05. GAUSS mbH (Institute for Environmental Protection and Safety in Shipping) (2009) 'Study of the Feasibility of Shore-Side Power Supply for the Ports of the Hanseatic City of Bremen. Summary of Findings'. Available at: https://sustainableworldports.org/wp-content/uploads/Study-of-the-Feasability-of-Shore-Side-Power-Supply-for-the-Ports-of-the-Haneatic-City-of-Bremen.pdf

06. Gemeente Rotterdam and Port of Rotterdam (2021) 'Strategy for Shore Power in the Port of Rotterdam'. Available at: https://www.portofrotterdam.com/sites/default/files/2021-05/strategy-for-shore-power-in-the-port-of-rotterdam.pdf

07. Karapidakis, E., Nikolaidis, E., Moraitakis, G., Georgakis, F. and Papadakis, M. (2022) 'Cold ironing feasibility study at the Heraklion port'. *Journal of Physics: Conference Series,* 2339, 012016. https://doi.org/10.1088/1742-6596/2339/1/012016

08. Karimpour, R. and Lara Lopez, J. M. (2022) 'EALING – European flagship action for cold ironing in ports. Executive Summary on Ports Questionnaire'. Available at: https://ealingproject.eu/wp-content/uploads/2022/05/Port-Questionnaires-Executive-Summary.pdf

09. Lacey, L., Brewster, P. and Fallen Bailey, D. (2019) 'The Development of Alternative Fuel Infrastructure in Irish Ports; A Feasibility Study'. *Irish Maritime Development Office,* Dublin, Ireland

10. Marinacci, C., Masala, R., Ricci, S. and Tieri, A., (2013) 'Technical-Economical Analysis of Cold-Ironing: Case Study of Venice Cruise Terminal'. *V International Conference on Computational Methods in Marine Engineering, MARINE 2013.* Hamburg, Germany, 29-31 May.

11. Nikolaidis Emm, Maniati M, (2023), Cost Benefit Analysis on the Electrification in the Port of Heraklion, CEF Project ELECTRIPORT

12. Strachinescu, A. (2021) 'Green Deal support for the Green Ports'. *Decarbonising Small and Medium Ports Event,* 7 July. Available at: https://portodeaveiro.pt/webinar-decarbonising-small-medium-ports/pdfs/session-three/2-Green-Deal-support-for-the-Green-Ports-Andreea-Strachinescu.pdf

13. Tseng, P.-H. and Pilcher, N. (2015) 'A study of the potential of shore power for the port of Kaohsiung, Taiwan: to introduce or not to introduce?' *Research in Transportation Business & Management,* 17, 83-91, ISSN 2210-5395, https://doi.org/10.1016/j.rtbm.2015.09.001.

14. Wang, H., Mao, X. and Rutherford, D. (2015) 'White Paper. Costs and benefits of shore power at the port of Shenzhen'. International Council on Clean Transportation, Woodrow Wilson International Center for Scholars. Available at: https://theicct.org/wp-content/uploads/2021/06/ICCT-WCtr_ShorePower_201512a.pdf

15. Wilske, A. (2009) 'Examining the Commercial Viability of Cold Ironing'. Available at: https://sustainableworldports.org/wp-content/uploads/Port-of-Gothenburg-Examining-the-Commercial-Viability-of-Cold-Ironing-2009.pdf

16. Wooley, D., Jones, B., Cheung, A. and Brito, J. (2021) 'Final Report. Maritime Port Clean Energy Infrastructure Jobs Study'. Available at: https://oceanconservancy.org/wp-content/uploads/2021/09/Maritime-Port-Clean-Energy-Infrastructure-Jobs-Study.pdf

17. Zanne, M. and Twrdy, E. (2021) 'The Economic Feasibility of Port Air Emissions Reduction Measures: The Case Study of the Port of Koper'.

18. Zis, T. (2019) 'Prospects of cold ironing as an emissions reduction option'. *Transportation Research. Part A: Policy & Practice,* 119, 82-95. https://doi.org/10.1016/j.tra.2018.11.003

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