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# How risky is the development of Offshore Wind Farms on a Mediterranean island?A case study in Paros, Greece

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ABSTRACT

Offshore Wind Farms (OWFs) play a key role in reducing reliance on fossil fuels and mitigating climate change. However, their feasibility and public acceptance remain uncertain due to environmental, economic, and societal concerns.

This study assesses the risks and opportunities of a hypothetical OWF development on the island of Paros, Greece. Using a structured Operational Risk Management approach, stakeholders—including government officials, local authorities, tourism representatives, NGOs, civil society, and academics—evaluated the project's potential negative and positive impacts across environmental, economic, and social dimensions.

Key findings reveal significant disagreements among stakeholders, particularly between local communities and government bodies. Environmental concerns, such as seafloor disruption, noise pollution, and bird collisions were prominent, while economic benefits like job creation and blue economy expansion were positively received. Social resistance, driven by the Not-In-My-Backyard effect, emerged as a major obstacle, highlighting the need for enhanced transparency, participatory planning, and public engagement.

The research emphasises the importance of inclusive decision-making, strategic risk mitigation, and effective communication to balance renewable energy goals with local concerns. While the project analysis offers considerable long-term benefits in energy security, environmental sustainability, and economic development, its success hinges on addressing socioeconomic and ecological challenges.

## 1. Introduction

The climate crisis is considered one of the most crucial challenges of the 21st century, with various impacts on the natural environment, human health and economic development (*Intergovernmental Panel on Climate Change (IPCC), Sixth Assessment Report*, 2021), underscoring the necessity for innovative and cooperative actions. At the same time, energy justice has become a prominent issue in the global discussion about sustainable development (Glasson et al., 2022). This concept emphasises the equitable distribution of the benefits and burdens associated with energy production and consumption, ensuring access to clean energy while safeguarding vulnerable populations from the adverse impacts of energy production.

In this context, Renewable Energy Sources (RES) play a vital role, as they offer clean and sustainable solutions for meeting energy needs, reducing dependence on fossil fuels and Greenhouse Gas emissions (GHGs). Nowadays, in Europe, large-scale Offshore Wind Farms (OWFs) projects have already been successfully implemented, primarily in the Northern European seas. OWFs are among the most dynamic RES applications, so their installation in sensitive areas with specific energy needs and challenges, such as islands, is crucial (Gkeka-Serpetsidaki et al., 2024). Integrating green power into these energy systems can offer significant advantages, ensure energy independence and improve energy security (May et al., 2021). However, the situation remains substantially different in the Mediterranean region, particularly on islands. Mediterranean islands face unique challenges: they are often energy-dependent due to their geographic isolation and dependence on costly imported fossil fuels (Kougias et al., 2019). At the same time, they host delicate marine ecosystems, biodiversity hotspots, and tourism-driven economies that may be vulnerable to large-scale offshore infrastructure projects. This combination of factors makes these areas especially relevant for research on the trade-offs between RES development, environmental protection, and social acceptance.

Despite the growing interest in offshore wind development in

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Southern Europe, much of the existing literature and policy discourse still prioritises techno-economic analyses, focusing on cost efficiency, technological feasibility, and energy yields. Social, economic, and ecological concerns, particularly in small insular communities, are frequently underexplored in both scientific studies and strategic planning (Devine-Wright and Howes, 2010; Wolsink, 2007; Nordregio, 2023). This gap raises several critical research needs.

Firstly, there is an urgent need to develop effective strategies to involve local communities early in offshore wind project planning. Understanding community perceptions is crucial for ensuring public acceptance and avoiding conflicts. Secondly, the economic impacts of OWFs on local communities require more research, particularly in tourism-dependent economies, where potential benefits or issues between renewable energy and traditional industries must be carefully examined. Thirdly, there is limited research on the policy and governance frameworks that can support socially fair offshore wind deployment, especially in regions with developing regulatory systems. Finally, a sustainability analysis should evaluate the potential environmental effects of OWFs on marine biodiversity, fishing zones, and local ecosystems through a balanced, multi-faceted risk assessment that extends beyond standard environmental impact statements.

This study addresses these challenges by applying an Operational Risk Management (ORM) approach to evaluate the potential risks and opportunities of a hypothetical offshore wind farm project in Paros, Greece. Although similar methods have been employed (Smaragdakis et al., 2020; Kamenopoulos and Tsoutsos, 2015; Betti et al., 2022), ORM has not yet been widely used in OWF planning within Mediterranean island contexts. This methodology enables the systematic identification and prioritisation of both positive and negative impacts across environmental, social, and economic aspects, while explicitly integrating stakeholder input into the assessment process.

Paros serves as an ideal case study due to its combination of high wind potential, dependence on tourism, sensitive marine ecosystems, and lack of existing offshore renewable projects. Notably, no OWF currently operates in Paros or elsewhere in Greece. However, recent policy developments, such as the Greek Ministry of Environment and Energy's Strategic Environmental Impact Study (2023) (E.D.E.Y. and E. Resources, 2023), have identified several areas in Greek waters as candidates for offshore wind development. This creates a timely opportunity to examine potential conflicts, explore stakeholder perceptions, and develop risk-informed, participatory approaches before initiating concrete projects.

To clarify how this study differs from conventional OWF assessments, Table 1 presents a comparative overview of the key methodological and thematic contributions of this work relative to typical OWF studies. Unlike standard approaches that often isolate environmental or economic factors, this research explicitly integrates socio-economic and ecological trade-offs using an ORM framework, incorporating stakeholder-driven data to inform policy recommendations based on participatory planning.

In the following sections, the paper first provides a brief overview of the current state of offshore wind energy, focusing on the specific challenges and opportunities for the Mediterranean region. It then introduces the study's methodological approach, explaining how the authors adapted the ORM framework to assess both the risks and benefits of a hypothetical offshore wind farm in Paros. The results section follows, presenting the findings from the stakeholder questionnaire, highlighting the perceptions of different stakeholder groups regarding the potential social, economic, and environmental impacts. In the discussion, these findings are interpreted within the broader context of energy transition planning for island communities, drawing attention to the importance of early stakeholder engagement and balanced risk assessment. Finally, the paper concludes by summarising the key insights, acknowledging the study's limitations, and proposing directions for future research.

**Table 1**
Key innovations of the current work.

| Aspect | This Study | Typical OWF Studies |
|---|---|---|
| Methodology | ORM-based stakeholder risk assessment | EIAs, cost-benefit analyses |
| Geographical Focus | Mediterranean island (tourism-dependent) | Northern Europe, large-scale projects |
| Stakeholder Analysis | Explicit conflict mapping (NIMBY vs. government) | General public acceptance surveys |
| Risk Integration | Combined socio-economic-ecological trade-offs | Often siloed (environmental OR economic focus) |
| Policy Recommendation | Participatory planning & transparency | Generic "improve public engagement" suggestions |

## 2. State-of-the-art

### 2.1. Offshore wind farms – Significance

Seas are characterised by stronger and more stable wind flows than land, so OWFs have significantly higher power generation than onshore. In this context, they play a critical role in achieving the goals set by the European Union (EU) with the Green Deal (European Commission, 2019), as the marine areas of Europe offer excellent conditions for wind farm development. These farms can produce vast amounts of clean energy, directly contributing to the reduction of GHGs and increasing the share of RES in the European energy mix.

In many countries, including Greece, OWFs are still in the early stages. However, the country's natural conditions (renewable energy potential and geomorphological features) are ideal for harnessing wind energy, indicating significant future potential. Between 2014 and 2023, Europe's annual installed OWFs capacity demonstrated consistent growth, from 1.5 GW in 2014 to 3.8 GW in 2023 (WindEurope, 2024). In 2023, Greece published the Strategic Environmental Impact Study (E.D.E.Y. and E. Resources, 2023), which identifies the potential environmental impacts of new projects and proposes measures to mitigate them.

While offshore wind development offers promising solutions for clean energy, its deployment is closely tied to issues of social acceptance and community involvement. Research has shown that public resistance has caused delays or even cancellations of OWF projects in multiple contexts (Devine-Wright and Howes, 2010; Wolsink, 2007). Nordregio's "Not Just a Green Transition" (NJUST) report (Nordregio, 2023) highlights the importance of participatory planning and stakeholder engagement to ensure both procedural and distributive justice in renewable energy transitions (ESPON Coordination Unit, 2011).

### 2.2. Challenges and opportunities

Although OWFs offer benefits and can support reliable energy independence, particularly in remote locations such as islands, they also present certain challenges. Therefore, a sustainable evaluation of OWF installations requires careful consideration of all potential factors that could impact the project's success either positively or negatively.

In this publication, these criteria were identified through a literature review of the impacts of OWFs on existing operational units during both the construction and operation phases, focusing on the environment, society, and the economy. Moreover, as highlighted by multiple reports, while significant progress has been made in understanding the impacts of construction and operation, decommissioning studies remain largely absent. This gap is important for lifecycle sustainability, especially in island contexts where long-term environmental, economic, and social liabilities influence stakeholder risk perceptions and acceptance, leaving major gaps in knowledge about the long-term consequences and lifecycle sustainability of these projects (Degraer et al., 2021).

#### 2.2.1. Societal challenges and opportunities

This section examines both the negative and positive impacts of offshore wind farms on the social fabric. Focusing on their effects on community life. The literature highlights concerns such as the loss of landscape experience values due to visual and noise disturbances (Hansen, 2024), impacts on ecological qualities affecting nature-based tourism, reduction in property values, and displacement of recreational activities (Nordregio, 2023). Furthermore, OWFs may change local social dynamics by introducing industrial elements into traditional landscapes, thereby influencing cultural identity and community cohesion. Additionally, studies have raised concerns about fair compensation, perceived inequity in benefit distribution, local administrative burdens, and increased living costs, all of which could heighten social tensions (Nordregio, 2023; Liburd et al., 2024).

While the literature generally considers serious accidents, leakages, and operational hazards to be rare in offshore wind farms, such risks are still perceived by stakeholders as potential concerns. Even low-probability events, such as labour accidents or operational failures with environmental consequences, can shape public attitudes, particularly in small island contexts where tourism and natural landscapes are highly valued. For this reason, these issues were included in our questionnaire to capture not only documented risks but also perceived ones, which play a key role in shaping social acceptance (Mou et al., 2021).

Another negative societal impact is widespread public distrust regarding the fair and proper allocation of financial resources. Unfortunately, there are numerous cases of public funds being misappropriated or spent. Many residents are reluctant to trust companies with self-serving aims (regardless of the overall positive impacts these projects might bring). They may view projects that deviate from the social norms of a small local community with suspicion (Skiniti et al., 2022; Gkeka-Serpetsidaki and Tsoutsos, 2022).

The analysis of OWF impacts also includes the potential positive effects on society. The publicity generated by such a project could positively affect the area, especially by attracting attention to renewable energy initiatives and sustainable tourism opportunities, such as attracting interest in renewable energy projects, creating opportunities for educational visits, or linking to emerging forms of eco-tourism that emphasise sustainable infrastructure. As noted earlier in the economic analysis, the publicity generated by such a project would also have a beneficial impact on the area. This can further benefit society, as a potential increase in tourism not only brings economic gains but also promotes cultural characteristics (Skiniti et al., 2022; Qehlmann and Meyerhoff, 2016).

Beyond the potential to improve population and area dynamics, better living conditions are expected to be provided to existing permanent residents. According to the National Development Programme for OWFs—Strategic Environmental Impact Study, such projects are anticipated to enhance energy supply and infrastructure within the Hellenic Electricity Transmission System (HETS), thereby improving residents' quality of life (E.D.E.Y. and E. Resources, 2023).

One of the most significant effects of an OWF project is the enhancement of public health, particularly in a place like Paros, which lacks a public hospital and has only a small health centre. Decentralised areas and islands gain strategic importance for monitoring and maintaining OWFs. This leads to better connectivity between these regions and nearby larger islands or mainland Greece, ensuring improved access to quality public health infrastructure (E.D.E.Y. and E. Resources, 2023).

Finally, participatory planning is essential for establishing and operating a large-scale development project, especially an OWF. Focusing primarily on the views of the local community and investors, a holistic participatory planning approach ensures sound decision-making for the project's successful realisation (Hansen, 2024; Hung et al., 2024).

### 2.2.2. *Environmental challenges and opportunities*

Regarding the environmental criteria identified in the literature, the first negative impact involves the reorganisation of the benthos. This disturbance leads to increased turbidity and changes in the flow of organic matter and debris. As a result, benthic anoxia, reduced light levels for primary producers, and physical damage to filter feeders may occur (Baulaz et al., 2023; Shen et al., 2024; Degraer et al., 2020). Similarly, the submarine relief is affected. Excavation and habitat disturbance for installing foundations and cables cause the death of infauna and aquatic species, as well as the loss of vital food sources. Consequently, this often triggers intense stress behaviours in species that may need to relocate from the construction zone (Baulaz et al., 2023; Dannheim et al., 2020).

Noise and vibrations from both the construction and operational phases of OWFs negatively affect marine organisms. Disturbances caused by seabed activities such as installing wind turbine bases in marine sediments, adversely affect nearby species. These activities can cause physical damage and stress, leading to behavioural changes and alterations in how species function within their environment. Furthermore, the noisy operation of wind turbines could impact several species, including crustaceans, fish, marine mammals, and birds, reducing their quality of life and creating survival challenges (Lindeboom et al., 2011; Petersen and Malm, 2006).

In terms of negative environmental impacts, the effects of lights and flickering shadows (caused by turbine blade movement) on certain species of fish, birds, and bats are also considered. The disruption of natural lighting patterns that these species use to maintain their cycles, such as nighttime feeding, reproduction, or migration, can lead to changes in their behaviour and survival. Moreover, the continuously flickering shadows caused by the rotating wind turbines may confuse species that rely on vision for navigation, foraging, or avoiding danger. This can reduce foraging success, increase predation risk, and increase the likelihood of collisions with other species or human-made structures (Garthe and Hüppop, 2004).

Furthermore, the impact of electromagnetic fields was assessed. Research shows that electromagnetic field impacts can cause behavioural changes in organisms, leading to stress and forcing them to interrupt their natural migration flows, reducing predation efficiency (Öhman et al., 2007). In addition, bird and bat collisions with turbine blades pose a significant ecological risk, especially for migratory and protected species. Finally, although metallic emissions from anti-corrosion processes are expected to remain within safe limits, they still raise concerns about marine pollution (Garthe and Hüppop, 2004). Additionally, metallic emissions from anti-corrosion processes are estimated to remain within safe limits, they continue to raise concerns about marine pollution (Golding et al., 2014; Kirchgeorg et al., 2018).

Despite these concerns, OWFs also provide notable environmental benefits. The climate crisis and the need for energy transition and GHG reduction are undeniable, and large-scale RES projects such as OWFs, are among the most feasible solution. Although during the construction and operational phases of OWF projects, an increase in direct and indirect GHGs (such as from construction material production and transport, and energy use during non-operational periods) can be expected, with the implementation of appropriate measures, these impacts will be low-intensity, cumulative, and ultimately offset by emissions reductions during OWF operation (Raoux et al., 2017).

Moreover, the presence of OWFs can promote biodiversity by creating artificial reefs that support colonisation by filter-feeding bivalves and pelagic fish. This phenomenon enhances the diversity and biomass of filter-feeding bivalves as well as pelagic fish. Additionally, an increase in predation is observed, while at the same time, a "stepping stone" effect may occur for non-native species on hard substrates (Glarou et al., 2020; Burkhard and Gee, 2012; Mangi, 2013). Additionally, fishing restrictions within OWF zones help enable natural reproduction, benefiting fish populations and improving biodiversity (Busch et al., 2011; Skiniti et al., 2024).

The deployment of OWF is also a matter of strategic energy importance, as wind speeds are typically stronger offshore. Wind speeds are generally higher over the sea than on land, leading to increased electricity generation. Even a small increase in wind speed significantly affects electricity production, as wind power relies on the cube of the wind speed. For example, an increase from 8 to 8.5 m/s (a 6 % rise) can result in approximately a 20 % increase in electricity output (E.D.E.Y. and E. Resources, 2023). Moreover, OWFs benefit from more stable wind conditions. Specifically, offshore wind turbines usually experience more consistent, less turbulent winds compared to the onshore, making them a more reliable energy source (Skiniti et al., 2024).

#### 2.2.3. Economic challenges and opportunities

Alongside environmental considerations, the economic effects of offshore wind farm (OWF) development have also been systematically examined, focusing on both potential benefits and negative impacts on local economies. Among the adverse effects, tourist businesses, restaurants, and dining venues may be affected due to the possible alteration of the coastal landscape and seascape views, which are vital to the island's tourism appeal. Simultaneously, the noise and visual disruptions caused by the construction sites may decrease visitor numbers to the area; noise and visual disturbances associated with onshore service facilities, such as construction bases or maintenance harbours, may temporarily impact the visitor experience and reduce local tourism activity. (Gkeka-Serpetsidaki and Tsoutsos, 2023)

Further economic concerns arise for professionals whose income depends directly on access to the marine and coastal zones affected during OWF development. These include fishermen, who may face temporary restrictions in certain fishing grounds during construction, and water sports operators whose access to coastal areas could be limited for safety reasons. However, in practice, such impacts are often minimised through Maritime Spatial Planning and designated safety zones, meaning that while some short-term disruptions are possible, significant long-term financial losses are unlikely (Devine-Wright and Howes, 2010).

Furthermore, OWF development may affect local property markets and land-use values. While installing energy infrastructure can attract new investment and stimulate urban regeneration, some stakeholders worry that altering the visual and coastal landscape could discourage tourism-based or heritage-sensitive development. This economic tension underscores the need for balanced regional planning that considers both investor appeal and the preservation of local identity (Nordregio, 2023).

On the other hand, the project brings many positive aspects to the local economy, among others. First, the planning, installation, and operation of the park generate local job opportunities for both skilled and unskilled personnel, including electrical and mechanical engineers for electrical connections, supervision, and task management, and staff for the transport and installation of infrastructure (Kim et al., 2020; Ladenburg, 2008).

Furthermore, the current policy landscape is shaped by the European Union's prioritisation of climate neutrality as a key goal. The European Green Deal has established a specific framework for energy transition and GHG reduction by 2050, complemented by other directives aimed at the same objective (European Commission, 2019). Thus, a project of this scale can serve as a promotional asset for the region, attracting alternative tourism such as renewable energy tourism, industrial heritage visits, or ecotourism initiatives that highlight sustainable infrastructure (Gkeka-Serpetsidaki and Tsoutsos, 2023).

As mentioned earlier, in the long term, local professionals dependent on the area could benefit from the park's operation. Combined with the area's publicity, new professional prospects and opportunities for tourism development linked to the project arise. This is evident in examples from the UK, Denmark, and the USA, where parks serve as attractions, either new sightseeing spots or recreational fishing tourism destinations (Parsons et al., 2020; Smythe et al., 2021).

Another significant contribution to the economy comes from the benefits of the circular economy (Regulation (EU) 2020/852) (European Union, 2020). This regulation emphasises the need to minimise waste and the release of hazardous substances throughout product life cycles to support sustainable production and consumption. The wind energy sector already incorporates circular economy principles in turbine component design. For instance, 85–90 % of wind turbine materials are currently recyclable, with ongoing innovation aimed at further improving blade recyclability (IRENA, 2021).

Lastly, understanding the impact on the blue economy is also essential. The blue economy encompasses all industries and sectors connected to oceans, seas, and coasts, whether directly involving the marine environment (such as shipping, marine food, energy production) or onshore (such as ports, shipyards, and coastal infrastructure). In a tourism-driven region like the island of Paros, synergies can also develop with other sectors of the blue economy, such as fishing and tourism (Hellenic Statistical Authority (ELSTAT), 2023).

To better frame the scope of this study, Fig. 1 illustrates the main challenges (left, red) and opportunities (right, blue) of OWF development as identified in the literature. Challenges include environmental issues (e.g., impacts on benthos, acoustic and electromagnetic disturbances), economic concerns (e.g., losses for businesses and professionals), safety risks, and societal suspicion. In contrast, opportunities highlight positive effects such as the improvement of the marine environment, contributions to the local economy, public safety, climate change mitigation, and improvements in social welfare. This schematic served as the conceptual foundation for structuring our ORM-based questionnaire and later interpreting stakeholder responses.

### 2.3. Summary and contribution

The literature highlights a broad range of potential challenges and opportunities related to OWFs. It also shows that most studies consider environmental, social, and economic aspects separately, without combining them into a single assessment framework. In particular, as noted in the Nordregio report (Nordregio, 2023), a key weakness in the current discussion around OWFs and the green transition is the limited inclusion of local viewpoints and participatory justice in project planning.

For example, Hansen (Hansen, 2024) and Liburd et al. (Liburd et al., 2024) highlight the tensions and synergies between wind energy and tourism, while Nordregio (Nordregio, 2023) discusses the broader challenges of ensuring a socially just green transition. Similarly, Tverijonaite et al. (Tverijonaite et al., 2024) draw attention to the fragmented nature of OWF research across sectors. This paper introduces an across-sectoral framework that combines these dimensions using an ORM methodology, with a particular focus on stakeholder perceptions within an insular Mediterranean context. By adopting a participatory approach, the study not only synthesises and expands existing insights but also tests a structured stakeholder tool in a real island setting.

## 3. Methodology

ORM systematically integrates multiple risk dimensions across environmental, social, and economic pillars (Kamenopoulos and Tsoutsos, 2015; International Organization for Standardization, 2018). ORM not only identifies potential negative outcomes (risks) but also recognises positive ones (opportunities), enabling a comprehensive understanding of the trade-offs involved. It is also participatory, ensuring that local perceptions and experiences are included in risk assessment processes. This feature is crucial, particularly in contexts where public acceptance is vital and social licence to operate can even threaten an investment (Skiniti et al., 2022). Implementing ORM in a participatory way helps to balance expert knowledge with community perceptions, fostering more transparent, inclusive, and resilient decision-making.

### 3.1. Case study: Paros Island

The island of Paros, situated in the Cyclades in the central Aegean Sea, was chosen as the case study for this research due to its distinctive energy, socioeconomic, and environmental characteristics. Paros is a

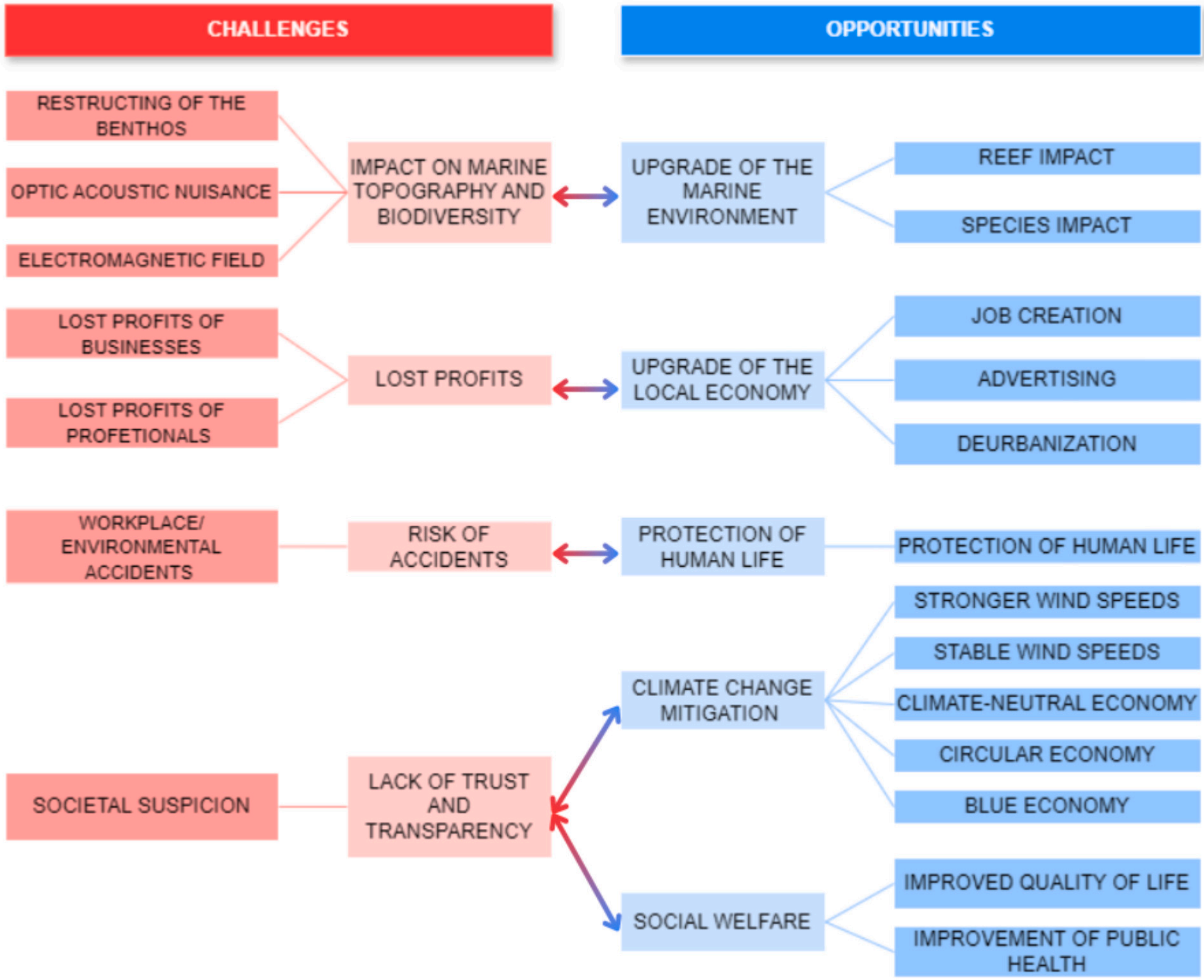


**Fig. 1.** Opportunities and mitigation strategies in offshore wind farms: Environmental, economic, and social impacts.

medium-sized island (Ladenburg, 2008) with a permanent population of around 14,520 residents, according to the 2021 census (Hellenic Statistical Authority (ELSTAT), 2023). Like many Mediterranean islands, Paros faces notable energy challenges, including a high reliance on imported fossil fuels, seasonal variations in energy demand driven by tourism, and vulnerability to energy price shocks. Meanwhile, Paros also has significant renewable energy potential, owing to its strong and steady wind resources, making it an attractive site for offshore wind development.

Furthermore, Paros illustrates the common challenges islands face regarding social acceptance of energy infrastructure projects. Its economy relies heavily on tourism, and the local community is strongly committed to protecting the island's landscape and marine environment. Therefore, using Paros as a reference point, the study aims to offer insights that can be applied to other Mediterranean or island settings with similar conditions, enhancing a broader understanding of sustainable offshore wind energy implementation in sensitive coastal and insular regions.

### 3.2. Processing method

Fig. 2 depicts the step-by-step methodology framework developed for the ORM assessment of offshore wind farms (OWFs), specifically focusing on a potential OWF project on Paros Island. The process starts with a thorough literature review, which primarily aims to identify the challenges and opportunities related to OWFs.

After these initial steps, the framework develops the ORM questionnaire, which is informed by the challenges and opportunities identified earlier. The questionnaire is then distributed to the selected stakeholders in the questionnaire distribution phase to gather their input. The next phase is data collection, where stakeholder responses are collected for analysis. Once the data is gathered, it feeds into the risk assessment framework, providing a structured approach to evaluate, categorise, and prioritise the identified risks.

Subsequently, the methodology proceeds to data ORM analysis, where the collected data are analysed using the ORM approach to generate insights on risk perception, prioritisation, and management strategies. Finally, the process concludes with result evaluation, where the analysis outcomes are critically assessed, and conclusions are drawn to inform future decision-making, stakeholder engagement, and mitigation planning.

In summary, this structured framework guarantees that the risk assessment is based on evidence from the literature, includes stakeholder perspectives, and utilises a systematic ORM analysis to support transparent risk management for OWF projects.

#### 3.2.1. Questionnaire

The research approach used in this study was based on a structured ORM questionnaire (ANNEX I. QUESTIONNAIRE). To develop the questionnaire, a targeted literature review was carried out to identify the key challenges and opportunities related to OWFs, with particular focus on the construction and operation phases. Because offshore wind development in Greece is still innovative and there is a lack of real-world data for the decommissioning phase, this study concentrated on the

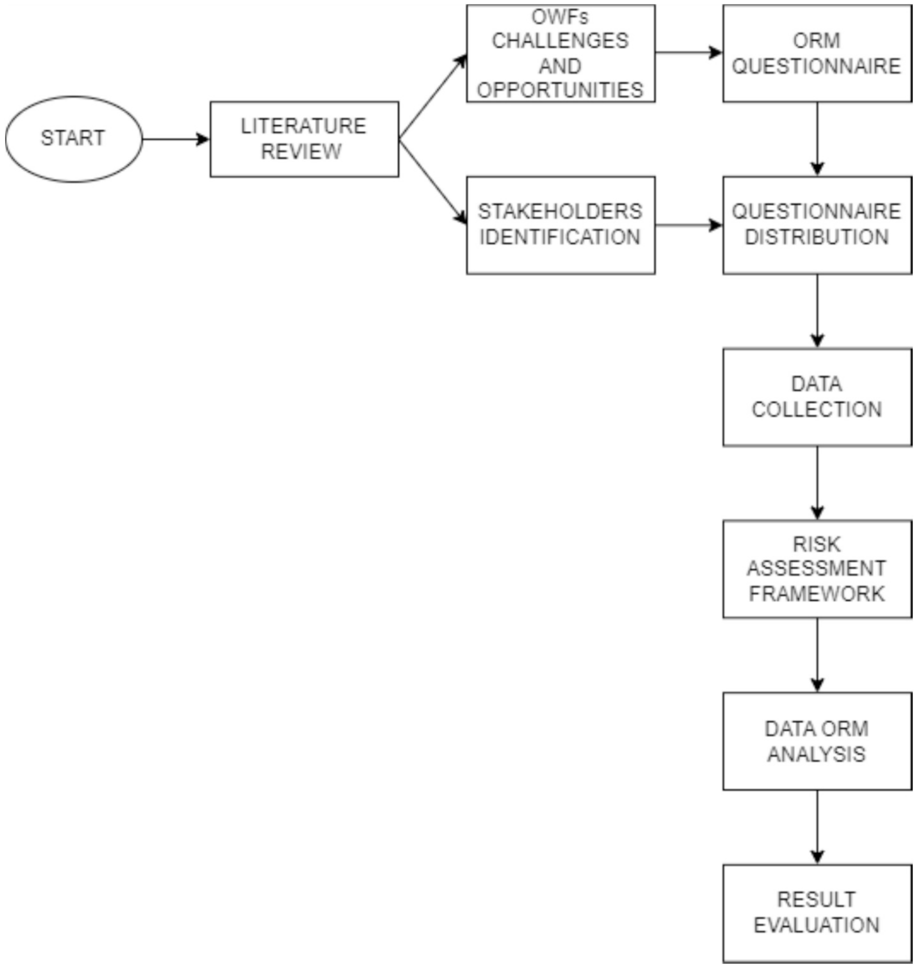


**Fig. 2.** Methodological framework - chart flow.

phases where stakeholders could more realistically assess impacts using existing knowledge and comparable experiences.

The questionnaire was organised around the three main pillars of sustainability: environment, economy, and society. For each pillar, criteria were devised to capture both potential positive impacts (opportunities) and negative impacts (risks), enabling a holistic assessment of offshore wind development. This integrated approach supports a more comprehensive understanding of how stakeholders perceive trade-offs and synergies in such complex renewable energy systems, complementing traditional techno-economic or purely environmental assessments.

For each pillar, the questionnaire is divided into two main parts: one addressing potential negative consequences and the other exploring positive outcomes. Each criterion within these sections is briefly described to ensure respondents understand its meaning without requiring technical background knowledge. Alongside each criterion, the phase of the process during which it occurs is indicated in parentheses, where "CP" stands for "Construction Phase" and "OP" for "Operation Phase." Subsequently, participants were asked to score both the severity of each impact (how serious it would be) and the likelihood of it occurring (how probable it is), so the results would reflect their perception of the importance and probability of these issues.

*3.2.2. ORM method*

ORM involves the identification, assessment, mitigation, and monitoring of risks present in the daily operations of a unit – in this case, OWFs. These risks include internal factors such as process inefficiencies, human error, and technological failures, as well as external events like regulatory changes, natural disasters, and geopolitical uncertainties. Through a comprehensive approach, ORM aims to proactively address vulnerabilities that may jeopardise the achievement of strategic objectives or stakeholders' interests (Smaragdakis et al., 2020).

Initially, participants are asked to evaluate each criterion in terms of its severity, with the option to choose from four categories, as displayed in Table 2.

Subsequently, a similar assessment is carried out for the probability of the same criterion occurring, with an option to select again from four predefined answers (Table 3).

During the questionnaire processing to derive the results, risk coding is necessary using Table 4 to better estimate the overall risk. The risk is characterised by the respondents' choices in the first two columns (SEVERITY and PROBABILITY).

Risks with codes 1 and 2 must be addressed immediately using specific measures. Risks with code 3 should be monitored and dealt with both now and in the future. Risks with codes 4 and 5 only need to be documented and can sometimes be ignored.

Of course, a different analysis is conducted for the project's negative

**Table 2**
Severity categories of the criteria.

| Level of severity | Explanation |
|---|---|
| A | Catastrophic |
| B | Critical |
| C | Marginal |
| D | Negligible |

**Table 3**
Level of probability categories of the criteria.

| Level of probability | Explanation |
|---|---|
| I | Likely to occur immediately or shortly. |
| II | Probably will occur in time. |
| III | Might occur in time. |
| IV | Unlikely to occur. |

**Table 4**
ORM table for the assessment of negative impact.

| RISK | PROBABILITY | | | |
|---|---|---|---|---|
| SEVERITY | A | B | C | D |
| I | 1 | 1 | 2 | 3 |
| II | 1 | 2 | 3 | 4 |
| III | 2 | 3 | 4 | 5 |
| IV | 3 | 4 | 5 | 5 |

The Risk Coding derived from Table 4 is as follows:
1 = Catastrophic (Red colour).
2 = Critical (Orange colour).
3 = Moderate (Yellow colour).
4 = Marginal (Blue colour).
5 = Negligible (Green colour).

impacts compared to its positive ones, as each varies fundamentally by nature and definition in terms of "risk." Therefore, Table 5 will be used to examine the positive impacts.

Impacts with codes 1 and 2 should be regarded as particularly significant for the relevant pillar of sustainability being assessed and are considered highly positive impacts of the potential OWF project. Impacts with code 3 are open to debate, and their outcomes will be monitored over time. Impacts with codes 4 and 5 should simply be recorded, as respondents considered them largely insignificant.

To interpret the results, the responses of each stakeholder group were combined using the ORM severity and probability matrices described above. For each risk or opportunity criterion, individual responses were gathered, and then the average was calculated within each stakeholder group. This method provided a reliable representation of the central tendency of opinions in each area, reducing the impact of extreme outlier values while preserving stakeholder differentiation.

**Table 5**
ORM table for the assessment of positive impact.

| RISK | PROBABILITY | | | |
|---|---|---|---|---|
| SEVERITY | A | B | C | D |
| I | 1 | 1 | 2 | 3 |
| II | 1 | 2 | 3 | 4 |
| III | 2 | 3 | 4 | 5 |
| IV | 3 | 4 | 5 | 5 |

The coding of impact derived from Table 5 is as follows:
1 = Remarkably positive impact (Green).
2 = Positive impact (Blue).
3 = Moderate impact (Yellow).
4 = Marginal impact (Orange).
5 = Negligible impact (Red).

For example, one of the negative impact criteria, "Intervention in the underwater relief" (construction phase), was assessed by stakeholders with an average risk score of 1.67, reflecting a highly critical risk category that would require immediate attention according to ORM prioritisation. Conversely, a positive opportunity criterion, such as "Job creation," was evaluated with an average impact score of 1.42 across stakeholder groups, indicating a notably positive opportunity that should be actively promoted in the project planning and communication strategy.

#### 3.2.3. *Stakeholder groups*

Stakeholders were initially identified through literature reviews of similar participatory studies (Wolsink, 2007), supplemented by local expertise and publicly accessible registries of local associations and institutions, mainly on Paros. Consequently, questionnaire recipients are local stakeholders from the island, divided into six main categories:

1. Local Authorities (LA) of the island: This category included two respondents, namely the Municipality of Paros and the Tourism Committee of the Municipality of Paros. They were selected because of their administrative and regulatory roles in land-use and marine planning.
2. Tourism and Economy sector (E&T): Consisting of 4 respondents (ERKYNA Travel, Paros–Antiparos Hoteliers Association, TERNA Energy, and the Paros Chamber of Commerce), this group was included to represent the economic actors most likely to be impacted by or to benefit from an OWF, given the island's strong tourism-based economy and the emerging potential for energy-sector investments.
3. NGOs and Environmental groups: This category involved 2 respondents from the Hellenic Society for the Protection of Nature and the Hellenic Society for the Environment and Cultural Heritage. Their participation was considered essential to address ecological and cultural heritage concerns, which are highly relevant in public debates about offshore wind energy in Greece.
4. Local Communities (LC): This group (2 respondents) comprised the NAIAS Nautical Club and the ARCHILOCHOS Cultural Association of Paros. These organisations were chosen to reflect community-level cultural, recreational, and social concerns related to changes in marine use and the local landscape.
5. Academic and Research stakeholders (AC): Involving 2 participants (the University of Crete and the Hellenic Centre for Marine Research, HCMR), this category contributed expert knowledge in marine ecology, energy systems, and policy, providing a scientific evidence base for evaluating offshore wind scenarios.
6. Government (GOV): This category included 2 respondents, namely the Centre for Renewable Energy Sources and Saving (CRES) and the Decentralised Administration of Crete to ensure perspectives from regulatory, policy-making, and strategic energy-planning institutions.

The 14 stakeholders were carefully chosen to reflect a diverse range of perspectives while keeping the sample size manageable for an exploratory risk assessment. Given the small population of Paros and the focus on local expertise, this targeted approach aligns with best practices for stakeholder engagement in risk perception studies (Reed, 2008). This sample size matches similar stakeholder-based operational risk assessments in community settings (Smaragdakis et al., 2020), where the goal is to explore perceptions rather than achieve statistical generalisation. Even a small number of experts in ORM can be valuable, provided strict procedures are followed, such as clear methodological steps, a diverse selection of experts to minimise bias, cross-checking among stakeholder groups, and utilising existing empirical or available data. Previous studies have used similar methods (Smaragdakis et al., 2020; Reed, 2008) focusing on depth of insight rather than statistical representation. Although the local population was not directly surveyed, their perspectives were indirectly captured through community organisations.

All stakeholders received the same questionnaire (they were recruited via email and phone contact) and assessed identical criteria to ensure consistency and comparability. Responses were grouped by stakeholder category, with the average score within each category calculated to reflect its collective perspective, thereby minimising the influence of outliers and considering uneven group sizes. Of the 21 questionnaire recipients, 14 participants completed the survey, resulting in a response rate of 67 %. The data collection period spanned from March 2024, when the first questionnaire was received, until July 2024, when the final response was obtained. Although the sample size is limited in absolute numbers, it aligns with similar stakeholder-based operational risk assessments in community settings (Smaragdakis et al., 2020), where the aim is to explore perceptions rather than to achieve statistical generalisation.

Following the ORM framework, each stakeholder evaluated the severity and likelihood of predefined risks and opportunities. These evaluations were then matched using the ORM matrix (Tables 4 and 5) to produce a numerical risk score. These scores were combined by stakeholder category, and the average was calculated to represent group-level perceptions. The results shown in Figs. 3–8 are based on these average scores, categorised by impact severity (1–5), and are colour-coded accordingly.

## 4. Results

### 4.1. Total evaluation of the sustainability challenges and opportunities of OWFs

Fig. 3 illustrates the key environmental challenges linked to OWFs, including seafloor restructuring, noise and vibration disturbances, light and shadow effects, electromagnetic fields, bird collisions, and marine pollution. The overall average ratings suggest that seafloor interventions, noise, and electromagnetic fields are regarded as some of the most concerning environmental risks.

Fig. 4 emphasises the environmental benefits of OWFs, including climate change mitigation, reef effects, positive impacts on species, and more resilient and stable wind speeds. The data indicates that reef effects and stable wind conditions are the most significant advantages, highlighting the role of OWFs in promoting marine biodiversity and ensuring the reliability of renewable energy.

Fig. 5 illustrates the economic concerns linked to OWFs, especially the financial effects on local businesses. The main issues reported include lost profits for tourism firms, professional services (fishermen and water sports operators), and seaside restaurants and bars. These challenges suggest potential disruptions in coastal economies caused by the installation and operation of OWFs.

Fig. 6 shows the economic benefits of OWFs, including key factors such as job creation, growth in the circular economy, a climate-neutral economy, expansion of the blue economy, advertising potential, and new professional opportunities. The most significant benefits are the creation of new jobs and professional opportunities, emphasising the potential for OWFs to support local and regional economic development.

Fig. 7 highlights the social risks of OWFs, including workplace accidents, societal suspicion, and environmental incidents. The most significant concern is workplace safety, followed by public scepticism about project transparency and environmental dangers. These findings underline the importance of public engagement and robust safety regulations for successful OWF implementation.

Fig. 8 illustrates the social benefits associated with OWFs, including advertising advantages, deurbanisation effects, enhanced quality of life, public health improvements, and human life protection. The data show that deurbanisation and quality of life improvements are the most highly valued benefits, emphasising the potential of OWFs to support rural revitalisation and overall well-being.

### 4.2. Evaluation of the sustainability challenges of OWFs per stakeholder group

Detailed graphs and numerical results supporting the analysis in this section are provided in Appendix II. These include the full set of scores for each stakeholder group across the identified risk and opportunity categories (Appendix II Table 1 and Table 2). A closer look at the risk coding system of Figs. 3–8 reveals significant differences between the different stakeholder groups, in terms of the severity of OWFs' challenges. More specifically:

#### 4.2.1. The Government (GOV)

The government consistently rates multiple risks as catastrophic or critical, emphasising its regulatory responsibility in reducing hazards. Marine pollution, electromagnetic fields, and environmental accidents emerge as the most urgent concerns. Interestingly, the government assigns a moderate risk to financial losses, contrasting with the Economy & Tourism sector's focus on these monetary risks. This indicates that government agencies are mainly concerned with long-term

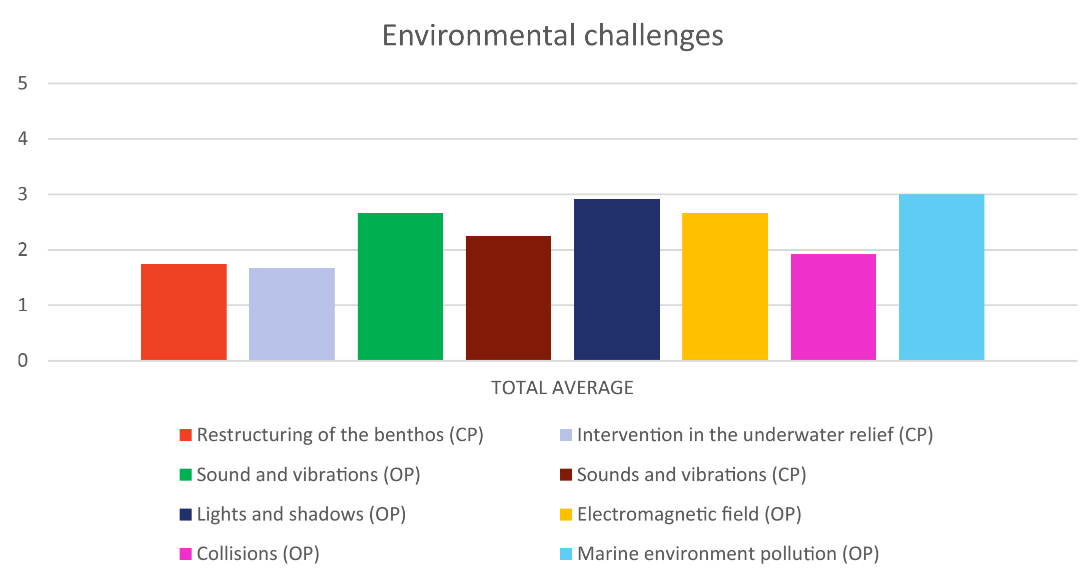


**Fig. 3.** Total evaluation of Environmental Challenges of Offshore Wind Farms.

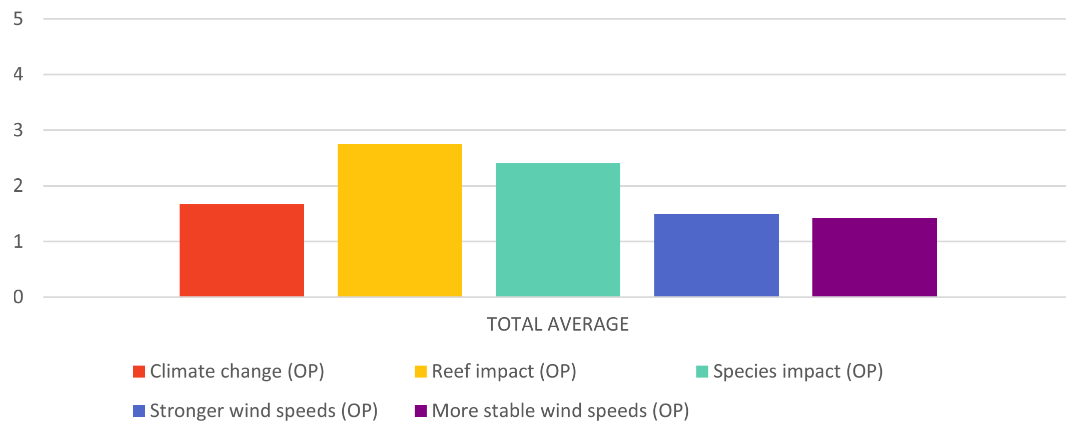


**Fig. 4.** Total evaluation of Environmental Opportunities of Offshore Wind Farms.

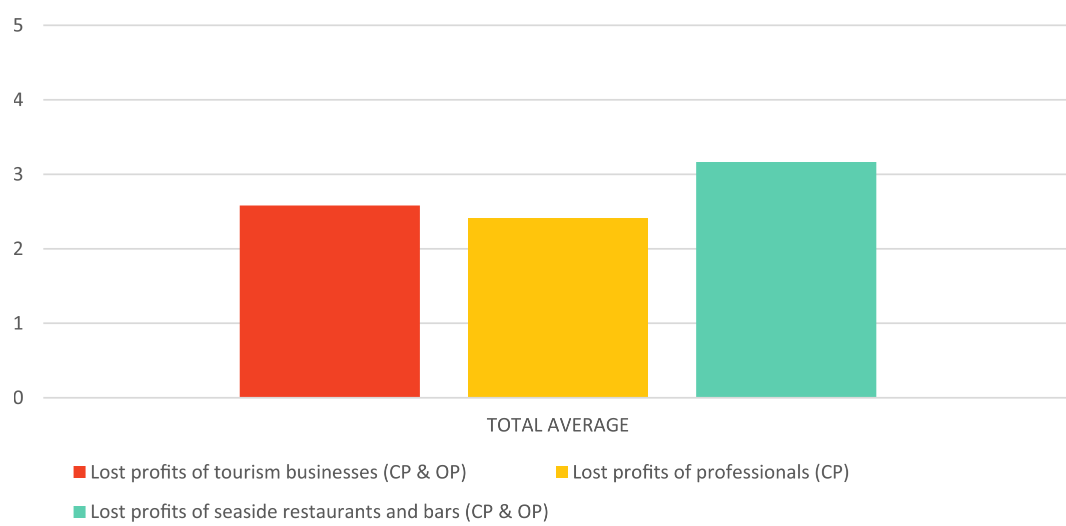


**Fig. 5.** Total evaluation of Economic Challenges of Offshore Wind Farms.

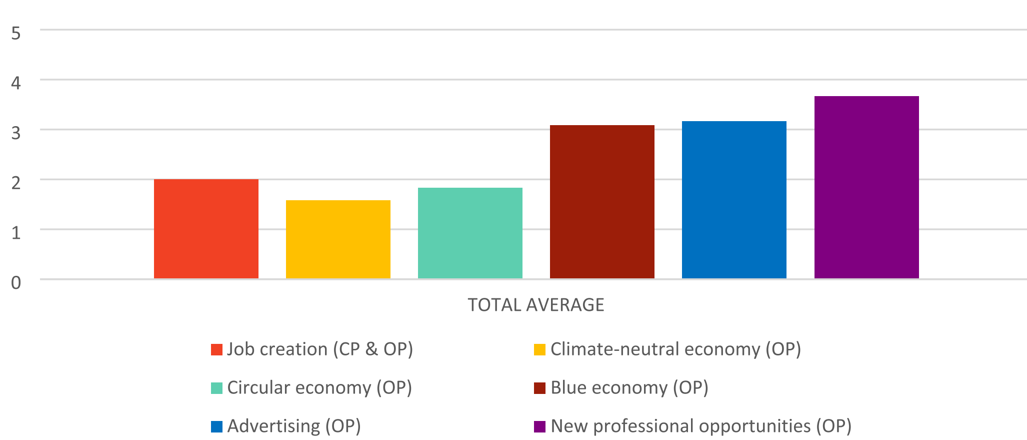


**Fig. 6.** Total evaluation of Economic Opportunities of Offshore Wind Farms.

environmental and operational risks rather than short-term financial disruptions.

Undoubtedly, the most typical example of conflicting interests is the dichotomy between local communities and the government. Local communities are more affected by the challenges of OWFs, as they are directly impacted by them (a manifestation of the NIMBY phenomenon). In contrast, governance tends to be more adaptable since its main focus is on increasing the RES share in the overall energy mix. The former faces pressure to cut emissions and therefore concentrates on development projects without particular regard for their specific location.

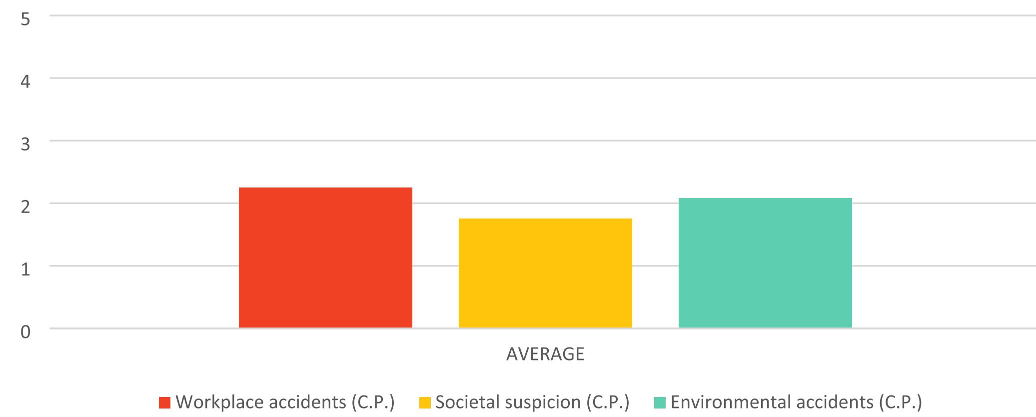


**Fig. 7.** Total evaluation of Social Challenges of Offshore Wind Farms.

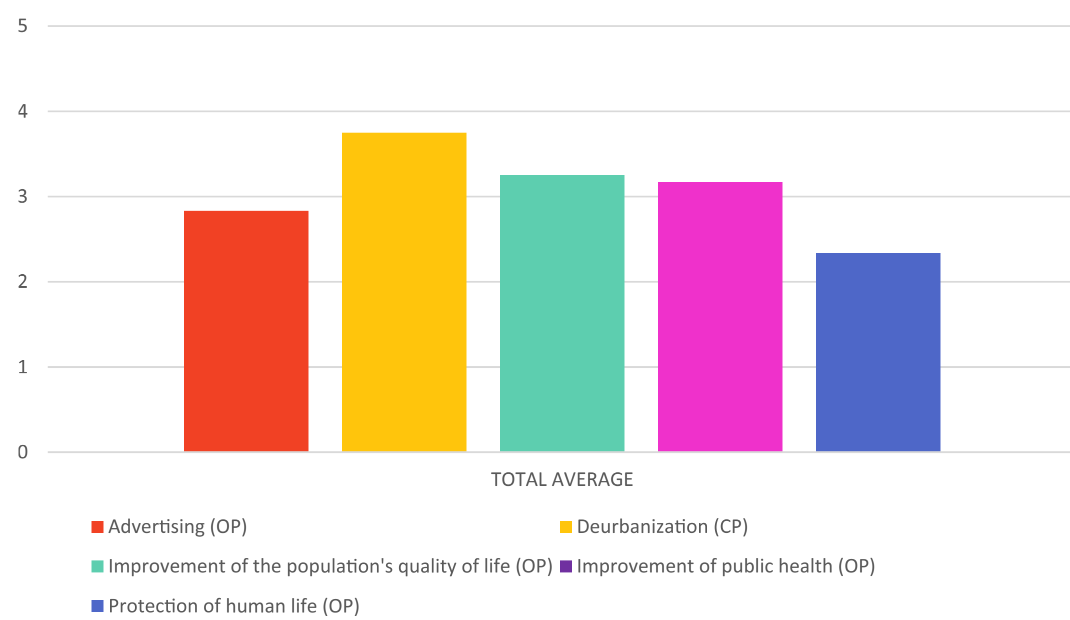


**Fig. 8.** Total evaluation of Social Opportunities of Offshore Wind Farms.

#### 4.2.2. *The Economy & Tourism (E&T)*

The Economy and Tourism sector considers collisions during operation as disastrous, greatly surpassing the concerns of other stakeholders. This strongly indicates that those involved in tourism and fisheries perceive direct economic damage from potential OWF-related disruptions to biodiversity and marine activities. Lost profits of seaside businesses and noise/vibration disturbances during operation are also viewed as crucial risks. This reflects fears that wind farms will affect coastal aesthetics, tourism appeal, and business sustainability.

#### 4.2.3. *Non-Governmental Organisations (NGOs)*

NGOs assign much lower risk levels to key environmental concerns than GOV and AC. They rate marine pollution as marginal (4), restructuring of the benthos, and underwater relief interventions as negligible. This is counterintuitive, as NGOs are typically more aligned with environmental advocacy. However, this might reflect a belief that proper mitigation measures can minimise these risks or a broader focus on long-term climate benefits rather than local ecological disturbances.

#### 4.2.4. *Local Authorities (LA) and Local community (LC)*

Local authorities assign risk levels ranging from moderate to critical, suggesting a balanced approach—neither dismissing nor overestimating the dangers of OWFs. Electromagnetic field exposure is considered critical by LA, reflecting public concerns about perceived health risks despite a lack of strong scientific consensus. Lost tourism profits are also rated as moderate, acknowledging economic concerns without overemphasising them. Noise and vibrations during operation are seen as only marginal issues by LA, reinforcing the idea that locals may adapt to such changes over time. Similarly, LC rates many risks as moderate to marginal, indicating a more pragmatic outlook than E&T or GOV. Overall, these two stakeholder groups are regarded as having a more balanced perspective on OWFs challenges.

#### 4.2.5. *The Academy (AC)*

The Academic group adopts a distinct stance, aligning with the government (GOV) in considering environmental and workplace risks as significant, but differing from NGOs and local authorities. Marine pollution is deemed critical, closely aligning with GOV. This suggests that AC stakeholders acknowledge the long-term ecological risks of OWFs, especially concerning water quality and marine biodiversity. However, their rating remains lower than GOV's, which is considered catastrophic, possibly due to confidence in mitigation technologies and the environmental benefits these projects can offer.

Lost profits of seaside businesses, workplace accidents, and professionals facing losses are considered moderate risks, indicating an awareness of economic impacts, but still a consequence that does not immediately harm the academy. Intervention in underwater relief is rated as moderate, alongside workplace accidents, while NGOs and LA view them as marginal. This is connected to the fact that academics have a greater awareness of the risks faced by workers, particularly those involved in offshore construction and maintenance.

Overall, the government, the economy, and the tourism sector see OWFs as highly risky, emphasising environmental and financial impacts, while non-governmental organisations downplay these concerns, trusting in mitigation. Local authorities and civil society adopt a balanced view, recognising risks but rating them as moderate or marginal. Academic stakeholders agree with the government on environmental risks but are less worried about economic impacts. These different perspectives highlight tensions between economic, environmental, and regulatory interests, underscoring the need for careful planning (ANNEX II, Table II.1.).

### *4.3. Evaluation of the sustainability opportunities of OWFs per stakeholder group*

#### *4.3.1. The Government (GOV)*

The government adopts a cautious stance on the benefits of OWFs, recognising their potential but not considering them transformative. Improvements in public health, the growth of the blue economy, and new professional opportunities are rated as moderately positive, indicating that while the government acknowledges these advantages, it does not see them as certain. Interestingly, climate-related benefits, such as contributing to a climate-neutral economy and reducing emissions, receive low ratings, suggesting that policymakers may regard OWFs as only a partial solution within a broader decarbonisation strategy.

#### *4.3.2. The Economy & Tourism (E&T)*

The economy and tourism sector evaluate OWFs with a mixed perspective, recognising certain economic benefits while remaining cautious about their overall impact. Deurbanisation, public health improvements, and advertising potential are viewed positively, suggesting that E&T stakeholders recognise how OWFs could support rural revitalisation and infrastructure development. However, they rate wind reliability, blue economy expansion, and climate benefits as moderate or marginal, showing scepticism about whether offshore wind projects will deliver long-term financial stability or tourism appeal. The hesitation in fully embracing OWFs suggests that while some business sectors may benefit, concerns remain about their overall economic viability.

#### *4.3.3. Non-Governmental Organisations (NGOs)*

NGOs are the most sceptical group regarding OWF benefits, giving low ratings to most environmental and economic opportunities. Reef impact, species impact, blue economy growth, and climate change mitigation are all seen as marginal or negligible, showing doubts about whether OWFs truly support biodiversity or effectively address climate change. This hesitation may come from concerns that industrial-scale wind farms disrupt marine ecosystems rather than boost their sustainability. Interestingly, NGOs also rate social and economic benefits lower than other groups, indicating a cautious view on whether OWFs will deliver lasting benefits for local communities.

#### *4.3.4. Local Authorities (LA) and Local Community (LC)*

Local Authorities (LA) and Local Communities (LC) are presented together in the results because their responses were highly aligned across almost all questions. This grouping highlights the strong convergence of views between these two stakeholder categories. Both groups, local authorities and civil society, are the most optimistic about OWF benefits, consistently rating economic and social opportunities as very positive or positive. They assign high scores to improvements in public health, deurbanisation, and new professional opportunities, reflecting a belief that OWFs can strengthen local economies, attract investment, and improve living conditions. LA highlights the blue economy and advertising potential, recognising OWFs as tools for regional branding and alternative tourism. Civil society shares this optimism but also strongly emphasises quality-of-life improvements, likely due to the potential for better infrastructure and energy security. The overall positivity from these two groups underscores grassroots enthusiasm for offshore wind projects, as they are viewed as engines for local progress.

#### *4.3.5. The Academy (AC)*

Academic stakeholders adopt a cautious yet data-driven approach, recognising some benefits while remaining sceptical about economic claims. Unlike NGOs, academics acknowledge moderate environmental benefits, such as impacts on reefs and species, suggesting that scientific analysis supports the idea that OWFs may create new habitats and enhance biodiversity under certain conditions. However, AC remains unconvinced by economic claims, considering job creation and climate-neutral economy benefits as marginal or negligible. This reflects concerns about the temporary nature of OWF-related jobs and the limited contribution of offshore wind to national energy transition goals. Regarding societal benefits, AC considers improvements in public health and deurbanisation as moderate, indicating uncertainty about whether these projects will significantly influence population dynamics or healthcare infrastructure.

Local authorities and civil society are the strongest supporters of OWFs, viewing them as catalysts for local development and improvements in quality of life. The government, the economy, and the tourism sector recognise the advantages but remain cautious, particularly concerning economic and climate impacts. NGOs are the most sceptical, questioning both environmental and economic claims, while academic stakeholders adopt a balanced stance, recognising some environmental benefits but doubting the long-term economic impact. These differences highlight the challenge of aligning national energy policy with local economic and environmental priorities, emphasising the need for inclusive decision-making (ANNEX II, Table II.2.).

### *4.4. Final hierarchy of key OWFs challenges*

The negative impacts of OWFs were ranked, emphasising that the most significant challenges mostly affect the environment and society, with economic impacts placed lower (ANNEX II, Table II.3.). Public scepticism appears as the most pressing issue, highlighting the need for greater transparency and public involvement in decision-making. Environmental concerns follow, including seafloor disturbance, bird collisions, and noise and vibration impacts, all showing the substantial pressure OWFs place on marine and coastal ecosystems. Economically, lost revenues from tourism and coastal businesses are seen as a major problem, signalling potential financial losses for local communities.

Overall, the findings highlight the need for a balanced approach in OWF development, making sure that social, environmental, and economic impacts are carefully considered to accomplish a sustainable and socially acceptable energy transition.

### *4.5. Evaluation of the sustainability opportunities of OWFs as a total*

The positive impacts of OWFs were also categorised (ANNEX II, Table II.4.), highlighting the substantial benefits across environmental, economic, and social domains. Environmental benefits were highly ranked, with the most important being stronger and more consistent wind speeds.

From an economic perspective, the shift towards a climate-neutral and circular economy, along with job creation, stands out as a vital benefit that enhances the economy's long-term sustainability. The growth of the blue economy and the development of new professional opportunities further highlight the economic potential of OWFs, which make significant contributions to employment and economic growth. On the social side, improvements in public health, quality of life, and human safety show clear societal advantages. However, these aspects are ranked lower in impact compared to environmental and economic factors.

## 5. Discussion

### 5.1. Environmental impacts

Stakeholder opinions on the environmental impacts of OWFs in Paros were notably divided, reflecting broader tensions in green energy transitions. Government and academic stakeholders emphasised strategic benefits such as increased wind yields and reductions in carbon emissions. Meanwhile, NGOs and local communities raised concerns about potential harms to biodiversity and marine ecosystems. Specifically, seafloor restructuring, noise pollution, and electromagnetic fields were highlighted as critical threats by many respondents, echoing concerns raised in earlier studies (Degraer et al., 2021; Hansen, 2024). Interestingly, NGOs rated these issues lower than anticipated, possibly indicating confidence in mitigation strategies or shifting environmental priorities. This supports earlier findings that perceptions are influenced not only by values but also by trust in governance mechanisms.

The research enhances the literature by applying ORM in a novel way that visualises these diverging perceptions and quantifies risk salience across stakeholder groups. It broadens existing knowledge on the necessity for dynamic marine spatial planning that incorporates local environmental concerns without neglecting broader decarbonisation goals. Overall, the findings align with previous literature but deepen understanding by providing detailed, context-specific comparisons among stakeholders. Unlike the recent review, which highlighted known ecological risks during construction and operational phases (e.g., seabed disturbance and species displacement), this study introduces an additional dimension by capturing perceived risk severity and likelihood among stakeholders within a Mediterranean island context. This contextual aspect is largely absent in the wider literature.

### 5.2. Economic impacts

Economically, the study revealed a nuanced perception of OWF impacts. Stakeholders from tourism and commercial sectors expressed concern over potential revenue losses from disrupted aesthetics and marine access, particularly during construction. These findings support previous work (International Organization for Standardization, 2018) suggesting that perceived risks to landscape quality can deter local business support. In contrast, academic and governmental actors highlighted long-term job creation, energy cost reductions, and blue economy synergies as more important.

The comprehensive review identified job creation and growth in the circular economy as consistent benefits, a view reinforced here, especially by government and local authority stakeholders. However, this study provides additional insight by showing how perceived economic risks vary significantly depending on local proximity to tourism and marine-based income sources. This level of detail confirms and broadens the literature focused on the spatial distribution of OWF economic costs and benefits.

### 5.3. Social impacts

As expected, social challenges proved to be particularly sensitive. Public distrust, reflected in worries about mismanagement, lack of transparency, and procedural unfairness, was considered among the most serious risks. This supports previous findings that mistrust, more than technical risks, often leads to public resistance to renewables (Skiniti et al., 2022; Hansen et al., 2024). Concerns about worker safety and the disruption of community identity were also widely shared.

The earlier review of the latest research highlighted limited focus on public health, local identity, and social equity in OWF contexts. This study directly addresses that gap by identifying significant perceived social benefits, particularly among local authorities and civil society groups. Opportunities such as deurbanisation, enhanced quality of life, and public health improvements were consistently recognised as important. This supports and builds upon OECD findings that infrastructure projects can promote rural revitalisation when adapted to local needs. Therefore, OWF development in Paros and similar island settings must include social value co-creation strategies to progress from mere technical feasibility to genuine social acceptance.

### 5.4. Cross-cutting challenges and policy implications

Although the technical potential of OWFs is recognised, the main point is that public perception, especially regarding fairness and governance, ultimately decides the project's success. Public scepticism, if not actively addressed through participatory approaches, could threaten otherwise feasible energy projects. The Paros case demonstrates that even within a small community, perceptions are deeply divided and closely align with stakeholder interests.

These findings support and extend existing calls (Nordregio, 2023; ESPON Coordination Unit, 2011) for more inclusive governance in the deployment of offshore renewable infrastructure. For Greece, this means that national policy must go beyond environmental impact assessments and adopt deliberative processes that prioritise local voices. Future offshore wind farm (OWF) development in Greece, particularly in tourism-driven island regions, must balance national energy ambitions with site-specific sensitivities. Compared to the current state-of-the-art, which often emphasises technical optimisation and cost-benefit analyses, this paper highlights that stakeholder-informed governance is equally vital to project feasibility.

In conclusion, the study enhances the literature by integrating environmental, economic, and social impacts within a unified ORM framework and demonstrating how stakeholder-specific insights can guide just transition strategies. Looking ahead, a participatory, adaptive governance model seems essential, not only for Paros but also for the wider Greek offshore wind agenda.

## 6. Research limitations and future proposals

During the research, notable limitations were identified. Firstly, a key difficulty was the lack of sufficient data for the demolition phase of OWFs, which restricted the assessment of environmental and socioeconomic impacts. Additionally, limited stakeholder participation posed challenges to data representativeness. Although responses were eventually collected from different groups, the process involved extending the data collection period to increase coverage and ensure more balanced input. This limitation should be taken into account when interpreting the findings, which remain exploratory in nature.

Furthermore, although this was not a major focus of the study due to its theoretical nature, social resistance from local communities posed some obstacles. This point, already discussed earlier, highlights the importance of engaging with community concerns early in the planning process.

Future research could examine the social acceptance of OWFs in different island regions, exploring communities with diverse cultural and socioeconomic backgrounds. Comparing these areas with Paros could provide valuable insights for enhancing the social acceptance of OWFs. Additionally, analysing the long-term environmental impacts of OWFs, including their effects on biodiversity and marine ecosystems, is essential for better understanding the consequences of wind farm operation. Furthermore, future studies could explore how innovative technologies, such as energy storage and smart grids, might influence perceptions and actual performance of OWFs, particularly regarding reliability, integration, and cost-effectiveness.

Finally, the relatively small sample of 14 stakeholders, while consistent with exploratory ORM applications (Smaragdakis et al., 2020; Reed, 2008), limits the generalisability of the results. Broader surveys involving the local population would be a valuable next step to validate these findings and explore potential NIMBY dynamics.

## AI statement

During the preparation of this work, the author(s) used GRAMMARLY to improve grammar and overall readability. After employing this tool/service, the author(s) reviewed and edited the content as necessary and take full responsibility for the content of the published article.

## Declaration of competing interest

None.


## Acknowledgments

None.


## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eiar.2025.108196.

## Data availability

The data that has been used is confidential.

## References


Baulaz, Y., Mouchet, M., Niquil, N., Lasram, F.B.R., 2023. An integrated conceptual model to characterize the effects of offshore wind. Ecosyst. Serv. 60, 101513.

Betti, A., Castaldo, R., Acampora, A., Montella, D., Astarita, A., 2022. A stakeholder-oriented approach for evaluating offshore wind farms: application to the Italian context. Frontiers in Energy Research 10, 973952. https://doi.org/10.3389/fenrg.2022.973952.

Burkhard, B., Gee, K., 2012. Establishing the resilience of a coastal-marine social-ecological system to the installation of OWFss. Ecol. Soc. 17 (4), 32.

Busch, M., Gee, K., Burkhard, B., Lange, M., Stelljes, N., 2011. Conceptualizing the link between marine ecosystem services and human well-being: the caseof OWFsing. International Journal of Biodiversity Science, Ecosystem Services & Management 7 (3), 190–203.

Dannheim, J., Bergstrom, L., Birchenough, S., Brzana, R., Boon, A.R., Coolen, J.W.P., Dauvin, J.-C., De Mese, I., Derweduwen, J., Gill, A.B., Hutchison, Z.L., Jackson, A.C., Janas, U., 2020. Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. ICES J. Mar. Sci. 77 (3), 1092–1108.

Degraer, S., Brabant, R., Rumes, B., Vigin, L., 2020. Special issue on understanding the effects of offshore wind energy development on fisheries. Oceanography Society 33, 48–57.

Degraer, S., Brabant, R., Rumes, B., Vigin, L. (Eds.), 2021. Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Empirical Evidence Inspiring Priority Monitoring, Research and Management. Royal Belgian Institute of Natural Sciences, OD Nature.

Devine-Wright, P., Howes, Y., 2010. Disruption to place attachment and the protection of restorative environments: a wind energy case study. J. Environ. Psychol. 30 (3), 271–280.

E.D.E.Y. & E. Resources, 2023. National program for the development of OWFs. In: Strategic Environmental Impact Study (SEIS), Athens.

ESPON Coordination Unit, 2011. Final Report. ESPON, Luxembourg. https://archive.espon.eu/sites/default/files/attachments/FinalReport_foreword_CU-16-11-2011.pdf.

European Commission, 2019. The European Green Deal. COM(2019) 640 final. Retrieved from. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF [Accessed: 5 March 2025].

European Union, 22 June 2020. Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment. In: Official Journal of the European Union, L 198, pp. 13–43 [Online]. Available: https://www.greenfinanceplatform.org/policies-and-regulations/regulation-eu-2020852-establishment-framework-facilitate-sustainable [Accessed: 5 March 2025].

Garthe, S., Hüppop, O., 2004. Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. J. Appl. Ecol. 41, 724–734.

Gkeka-Serpetsidaki, P., Tsoutsos, T., 15 January 2022. A methodological framework for optimal siting of offshore wind farms a case study on the island of Crete. Energy 239 (Part D), 122296. https://doi.org/10.1016/j.energy.2021.122296.

Gkeka-Serpetsidaki, P., Skiniti, G., Tournaki, S., Tsoutsos, T., 2024. A review of the sustainable siting of offshore wind farms. Sustainability 16 (14), 6036. https://doi.org/10.3390/su16146036.

Gkeka-Serpetsidaki, P.T., Tsoutsos, T., 2023. Integration criteria of offshore wind farms in the landscape: viewpoints of local inhabitants. J. Clean. Prod. 417 (10), 137899. https://doi.org/10.1016/j.jclepro.2023.137899.

Glarou, M., Zrust, M., Svendsen, J.C., 2020. Using artificial-reef knowledge to enhance the ecological function of offshore wind turbine foundations: implications for fish abundance and diversity. J Mar Sci Eng 8 (5), 332.

Glasson, J., Durning, B., Welch, K., Olorundami, T., 2022. The local socio-economic impacts of offshore wind farms. Environ. Impact Assess. Rev. 95, 106783. https://doi.org/10.1016/j.eiar.2022.106783.

Golding, L., Angel, B., Batley, G., Apte, S., Krassoi, R., Doyle, C., 2014. Derivation of a water quality guideline for aluminium in marine waters. Environ. Toxicol. Chem. 34 (1), 141–151.

Hansen, A.S., 2024. Bridging tourism and energy industry development in coastal-marine peripheries: the case of Bornholm, Denmark. Tour. Mar. Environ. 19 (2), 109–120. https://doi.org/10.3727/216901924X17186068045875.

Hansen, A.S., Manniche, J., Larsen, K.T., 2024. Navigating sustainable transition processes at the local level: the case of Energy Island Bornholm. Environ. Innov. Soc. Trans. 53, 100930. https://doi.org/10.1016/j.eist.2024.100930.

Hellenic Statistical Authority (ELSTAT), 2023. 2021 Population and Housing Census: Final Results [Online]. Available: https://www.statistics.gr/en/2021-census-pop-hous [Accessed: 5 March 2025].

Hung, F., Ghaffari, A., Yang, Y.C.E., Dillingham, G., 2024. An investment behavioral modeling framework for advancing power system transformation toward renewable energy integration. Energy Clim. Chang. 5, 100127. https://doi.org/10.1016/J.EGYCC.2024.100127.

Intergovernmental Panel on Climate Change (IPCC), Sixth Assessment Report, 2021.

International Organization for Standardization, 2018. ISO 31000:2018 — Risk management — Guidelines. ISO, Geneva, Switzerland.

IRENA, 2021. Future of Wind: Deployment, Investment, Technology, Grid Integration and Socio-Economic Aspects.

Kamenopoulos, S., Tsoutsos, T., 2015. Assessment of the safe operation and maintenance of photovoltaic systems. Energy 93 (2), 1633–1638. https://doi.org/10.1016/j.energy.2015.10.037.

Kim, J.-H., Nam, J., Yoo, S.-H., 2020. Public acceptance of a large-scale offshore wind power project in South Korea. Mar. Policy 120, 104141.

Kirchgeorg, T., Weinberg, I., Hörnig, M., Baier, R., Schmid, M.J., Brockmeyer, B., 2018. Emissions from corrosion protection systems of OWFss:Evaluation of the potential impact on the marine environment. Mar. Pollut. Bull. 136, 257–268.

Kougias, I., Szabó, S., Nikitas, A., Theodossiou, N., 2019. Sustainable energy modelling of non-interconnected Mediterranean islands. Renew. Energy 133, 930–940. https://doi.org/10.1016/j.renene.2018.10.090.

Ladenburg, J., 2008. Attitudes towards on-land and offshore wind power development in Denmark; choice of development strategy. Renew. Energy 33 (1), 111–118.

Liburd, J., Dragin-Jensen, C., Hjalager, A.M., 2024. Tourism and Turbines: An Exploratory Literature Review of the Relations between Tourism and Wind Turbines. Innovation and Culture, University of Southern Denmark, Kolding, Center for Tourism.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N., Bouma, S., Daan, R., Fijn, R.C., de Haan, D., Dirksen, S., van Hal, R., Lambers, R. Hille Ris, ter Hofstede, R., Krijgsveld, K.L., Leopold, M., Scheidat, M., 2011. Short-term ecological effects of an OWFs in the Dutch coastal zone; a compilation. Environ. Res. Lett. 1341 (6), 035101.

Mangi, S., 2013. The impact of OWFss on marine ecosystems: a review taking an ecosystem services perspective. IEEE 101 (4), 999–1009.

May, R., Jackson, C.R., Middel, H., Stokke, B.G., Verones, F., 2021. Life-cycle impacts of wind energy development on bird diversity in Norway. Environmental Impact Assessment Review 90, 106635. https://doi.org/10.1016/j.eiar.2021.106635.

Mou, J., Jia, X., Chen, P., Chen, L., 2021. Research on operation safety of OWFs. J Mar Sci Eng 9 (8), 881. https://doi.org/10.3390/jmse9080881.

Nordregio, 2023. Not just a green transition: examining the path towards a socially just green transition in the Nordic region. Nordic Council of Ministers. https://doi.org/10.6027/temanord2023-542.

Öhman, M.C., Sigray, P., Westerberg, H., 2007. Offshore windmills and the effects of electromagnetic fields on fish. AMBIO A Journal of the Human Environment 36 (8), 630–633.

Parsons, G., Firestone, J., Yan, L., Toussaint, J., 2020. The effect of offshore wind power projects on recreational beach use on the east coast of the United States: evidence from contingent-behavior data. Energy Policy 144, 111659.

Petersen, J.K., Malm, T.K., 2006. Offshore windmill farms: threats to or possibilities for the marine environment. AMBIO: A Journal of the Human Environment 35 (2), 75–80.

Qehlmann, M., Meyerhoff, J., 2016. Stated preferences towards renewable energy alternatives in Germany – do the consequentiality of the survey and trust in institutions matter? J. Environ. Econ. Policy 6 (1), 1–16.

Raoux, A., Tecchio, S., Pezy, J.-P., Lassalle, G., Degraer, S., Wilhelmsson, D., Cachera, M., Ernande, B., Le Guen, C., Haraldsson, M., Grangeré, K., Le Loc'h, F., Dauvin, J.-C., Niquil, N., 2017. Benthic and fish aggregation inside an OWFs: which effects on the trophic web functioning? Ecol. Indic. 72, 33–46.

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141 (10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014.

Shen, H., Crespo del Granado, P., Jorge, R.S., Löffler, K., 2024. Environmental and climate impacts of a large-scale deployment of green hydrogen in Europe. Ener. Climate Change 5, 100133. https://doi.org/10.1016/j.egycc.2024.100133.

Skiniti, G., Daras, T., Tsoutsos, T., Nov 2022. Analysis of the community acceptance factors for potential wind energy projects in Greece. Sustainability. https://doi.org/10.3390/su142316009.

Skiniti, G., Lilli, M., Skarakis, N., Tournaki, S., Nikolaidis, N., Tsoutsos, T., April 2024. A holistic approach for tourism carrying capacity estimation in sensitive ecological areas. In: Environment, Development and Sustainability. Nature-Springer. https://doi.org/10.1007/s10668-024-04805-0.

Smaragdakis, A., Kamenopoulos, S., Tsoutsos, T., 10 July 2020. How risky is the introduction of fuel cell electric vehicles in a Mediterranean town? Int. J. Hydrogen Energy 45 (35), 18075–18088. https://doi.org/10.1016/j.ijhydene.2020.04.224.

Smythe, T., Bidwell, D., Tyler, G., 2021. Optimistic with reservations: the impacts of the United States' first OWFs on the recreational fishing experience. Mar. Policy 127, 10440.

Tverijonaite, E., Sæþórsdóttir, A.D., Ólafsdóttir, R., Hall, C.M., 2024. The interrelationships between renewable energy infrastructure and tourism: a thematic literature review. Environmental Development 52, 101080. https://doi.org/10.1016/j.envdev.2024.101080.

WindEurope, Feb. 2024. Wind energy in Europe: 2023 Statistics and the outlook for 2024–2030. In: https://proceedings.windeurope.org/biplatform/rails/active_storage/disk/2023.pdf.

Wolsink, M., 2007. Wind power implementation: the nature of public attitudes, and the role of local context. Energy Policy 35 (5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.002.