MERMAID

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Socio-economic Analysis of the Mediterranean Site

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1 Introduction and scope of the deliverable

1.1 Goals and objectives of the deliverable

MERMAID aims at integrating and improving today's technology in an optimal way in order to enhance economic feasibility, reduce environmental impact and to increase the use of ocean space at specific sites, by means of Multi-Use Offshore Platforms (MUOPs). In MERMAID, business opportunities associated with MUOPs are investigated in four different locations in Europe through a financial assessment. In addition, MERMAID aims at identifying the impact on human welfare of MUOPs through a framework for socio-economic assessment. This framework takes into account the fact that human welfare is dependent on a wide range of social and economic aspects, including ecosystem services.

The overarching aim of this deliverable is to assess the sustainable development of the final conceptual designs of MUOPs. Sustainable development is described by a three-dimensional sustainability condition. In particular, in the framework of analysis, sustainable development is achieved when the following conditions are simultaneously satisfied:

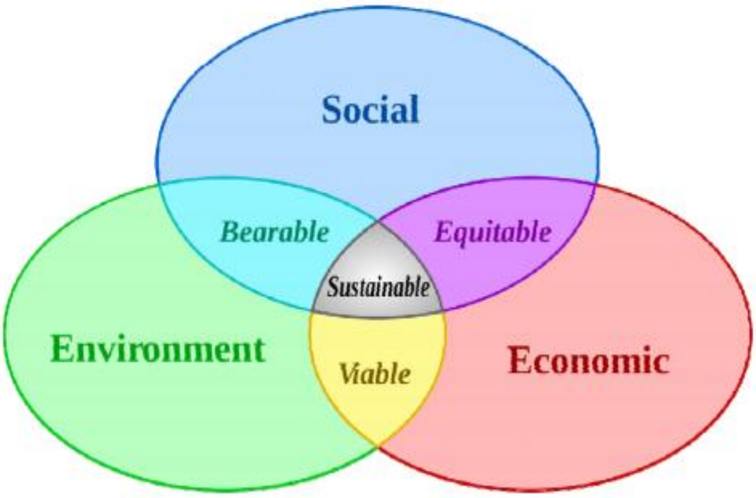

Figure 1 Spheres of Sustainable Development (W.C.O.E.A.D./Brundtland Commission, (1987); UN (2015)

a. Dynamic and Spatial Economic Efficiency and Sustainability: Economic efficiency satisfies the condition that the marginal (social) cost of each production activity under consideration equals the respective marginal (social) benefit. Hence, in this framework both private and social components of costs and benefits are considered in order to provide an integrated economic assessment in terms of efficiency. When the economic efficiency condition is satisfied over time (inter-generationally) and over space (intra-generationally) the economic sustainability of the considered production activities is achieved.

b. Dynamic and Spatial Social Equity and Sustainability: Social equity requires that the social effects of the production activities under consideration are bearable and equitable by the different social groups identified in the region under investigation. These affordability and acceptability conditions should be relevant spatially (intra-generational effects) but also dynamically (inter-generational effects).

c. Dynamic and Spatial Environmental and Ecological Sustainability: Environmental and Ecological Sustainability means that the environmental and ecological effects of the activities under consideration are sustainable over space (in the region under consideration) but also over time.

In this deliverable, we examine the possibility of sustainable development of the developed conceptual MUOP design by socio-economically assess the envisioned MUOP to be placed in the **Mediterranean.**

The selected area is the **Northern Adriatic Sea**, East of Italy and specifically off the shore of Venice. It is a test area presenting a set of complex challenges. These challenges include:

- lowest marine renewable energy potential in the Mediterranean;
- mild slope of 0.35 m/km and peculiar circulation patterns with a high seasonal variability;
- large anthropogenic development, which leads also to erosion and land subsidence;
- strategic area for marine fauna conservation, sheltering relevant seabird populations and endangered marine mammals;
- the vicinity of the city of Venice, with the associated high social sensitivity to the construction of new marine infrastructures.

The selected MUOP includes wind turbines and fish farming. The fish farm is designed to support annual production capacity of 2000 tons, equally divided between the gilthead sea bream (*Sparusaurata)*andEuropean sea bass (*Dicentrarchuslabrax*) species. To assure good fish health, the bottom depth at installation the bottom depth at installation must be at least 2 times the depth of the nets.

The wind farm consists of 4 VESTAS V112, which is characterized by a 112 m rotor diameter and by a rated power of 3.3 MW. The total production is of 12.7 GWh/y, with around 1000 equivalent hours. To reduce wake effects a spacing of 7 rotor diameters (distance of around 800 m) around each wind generator is assumed.

MUOP's occupied space is a square area of 0.64 km^2, where the wind turbines are placed at the corners and the fish farm in the middle. This configuration allows sufficient spacing around the cages for water circulation and sailing. More detailed information about the decisions of the MUOP design can be found in the rest of MERMAID Deliverables (e.g. MERMAID D7.2, MERMAID D7.3).

Table 1 Mediterranean Site Factsheet

Geographical location	Northern Adriatic Sea, off the coast of Venice
Offshore distance	16km
Depth	16m, gentle slope towards south east
Substrate	A mixture of sand and mud
Water temperature	14^{o}C (+/- 6^{o}C)
Salinity	27.5psu (+/- 1.5psu)
Tidal range	0.5 m (+/- 0.15m)
Mean wave height	1.25 m
Expected annual wave power	3 kW/m
Average wind speed	4.54 m/s
Expected annual wind power	Large turbines: 12.7 GWh/y/4 Vestas V112 turbines

1.2 Relationship to overall project objectives

This deliverable presents the results of the application of the Methodology for Integrated Socio-Economic Assessment (MISEA) which was developed in MERMAID (MERMAID D8.1) to socio-economically assess the different proposed designs of novel Multi-Use Offshore Platforms (MUOPs). MISEA assists on identifying, not only the potential range of impacts of a proposed investment such as the construction of MUOPs, but also the likely responses of those impacted by the investment project. Since it is anticipated that these novel designs of platforms will have considerable socioeconomic and environmental impacts, MISEA provides an analytical framework that lies in agreement with the sustainability conditions. MISEA assists on designing appropriate mitigation strategies to minimize negative and maximize positive socio-economic and environmental impacts. In this context, this methodology extends the standard process of financial analysis into an assessment that incorporates socio-economic, legal, technological environmental parameters.

In particular, the methodology allows a stepwise approach of integrating information produced in the previous work packages (WPs) of the project towards the socio-economic assessment of different designs (being built by the engineers of MERMAID in previous WPs) of MUOPs. The multi-disciplinary information, allows a direct comparison between different MUOP designs, including comparison between multi-use and single-use alternatives. Under MERMAID, the information produced by the different WPs was used for the socio-economic assessment in each selected site and platform design.

- Legal and policy analysis provided the policy and legal background required for the development of the particular platform designs. Stakeholders' analysis and more specifically the stakeholders' roundtables provided inputs to for the final design and the socio-economic assessment of the selected MUOPs with regards to social acceptance and potential conflicts between stakeholders (MERMAID D2.1, MERMAID D2.4 and MERMAID Repository[1]: Regional Profiling Datasets).

- The identification of innovative platform designs formed the background required for the collection of the financial data, as well as the socio-economic analysis and monetization of environmental externalities. (MERMAID D7.1, MERMAID D7.2, MERMAID D7.3, and MERMAID Repository[2]: Regional Profiling Datasets).

- The case-study specific environmental assessments (MERMAID Repository[3]: Regional Profiling Datasets) identified the environmental effects in relation to the suggested designs. MUOPs are related to a stream of new social/environmental goods and services (e.g., increase of employment, increase food and energy security, potential interactions with marine environment etc.) with no values readily observed in existing markets. Hence, it was required to follow non-market economic valuation methods to estimate these values (Economic Valuation Methods are explained in D8.1). Although the information was limited and based on experts' opinions and stakeholder's views, the economic values of the main environmental externalities were estimated successfully.

- The case-study specific financial feasibility assessment was crucial for the comparison between different offshore platforms. The data used in the financial assessment were the investment costs with regards to equipment, construction, labor and other costs, as well as operation data for the costs and revenues according to different functions used in the final design of each study site (e.g. energy/aquaculture production output, price, raw materials, energy used, maintenance costs, operating costs).

This methodology provided useful information on which economic activities should be implemented on the different sites, with the scope to avoid developments that would have negative socio-economic and environmental consequences, considering legal and technical aspects. This load of information assists on identifying challenges and opportunities towards the implementation of suggested MUOPs. A representation of the connections between the WPs' outputs used as inputs is given below.

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[1] http://mermaid.madgik.di.uoa.gr/
[2] http://mermaid.madgik.di.uoa.gr/
[3] http://mermaid.madgik.di.uoa.gr/

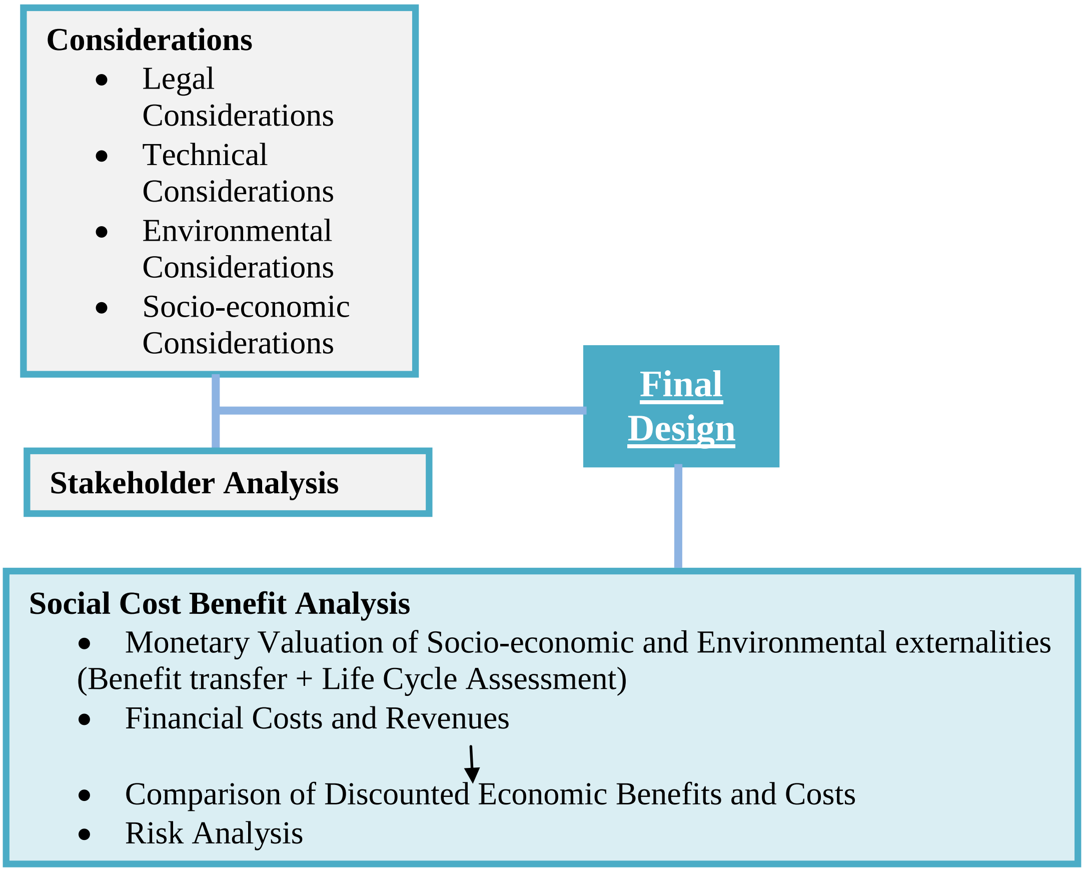

Figure 2 MERMAID Stepwise approach of integrating information

1.3 Outline for the reader

The document is divided into **6** different sections. **Section 2** describes the general methodology framework of the conducted assessment and introduces the online assessment tool as the application of this methodology. **Section 3** includes a regional description of the Mediterranean Sea site. **Section 4** describes the economic valuation of environmental changes. **Section 5** includes the financial assessment for the Mediterranean Sea site. **Section 6** includes the undertaken social cost benefit analysis and **Section 7** offers concluding remarks and recommendations.

2 General framework of the methodology and introduction to the Assessment Tool

2.1 The methodology for Socio-economic Assessment of MUOPs

In this section the Methodology for Integrated Socio-economic Assessment (MISEA) is described in detail. This methodology allows us to identify, valuate and assess the potential range of impacts of different feasible designs of MUOP investments, and the responses of those impacted by the investment project. This methodology aims to investigate the possible sustainable development of MUOP investments, by focusing on marine sustainable management, extending the standard process of financial analysis into an interdisciplinary assessment that incorporates socio-economic, technological, legal and environmental parameters, parameters, aiming at an estimation of the total impact on economic welfare in society.

Economic welfare includes the net benefit earned by a private company, as well as the total benefit /cost to the national economy. If we want to capture the total economic value of a project we need to consider the socio-economic and possible environmental impacts to the ecosystem.

Socio-economic impacts can be characterized as “direct” and “indirect”. This distinction is with regards to the level of effect on those who are involved in the MUOPs, meaning that particular economic sectors and people can be affected directly and/or indirectly by the use and operation on MUOPs. Direct impacts correspond to the earning capacity and costs of aquaculture, energy and maritime business, concerning for example the employees and their families, as well as the suppliers of aquaculture, energy and maritime businesses. Indirect impacts on the other hand are related to impacts on consumers and the broader economy.

Based on the analysis produced under each MUOP design for each site and the stakeholders’ views (MERMAID D2.4), MUOPs will create new employment opportunities and will have strong economic impact in the community. Enterprises will benefit by the development of new technologies and will improve the technical capacities for energy production and aquaculture. In addition, MUOPs have the potential to increase research and development regarding technological advances and to boost educational aspects.

Accordingly, implementing an MUOP would affect the environment and the ecosystem services. Ecosystem services are defined as services provided by the natural environment that benefit people (Defra, 2007). Individuals place values on the environmental resources and their ecosystem services for given changes in their quality and/or quantity, which are expressed in relative terms based on individuals’ preferences. Based on the MERMAID EIA manual, experts opinions of the MERMAID project and Life Cycle Assessment (LCA), environmental effects were identified. These were linked to human welfare and their value was elicited using economic theory.

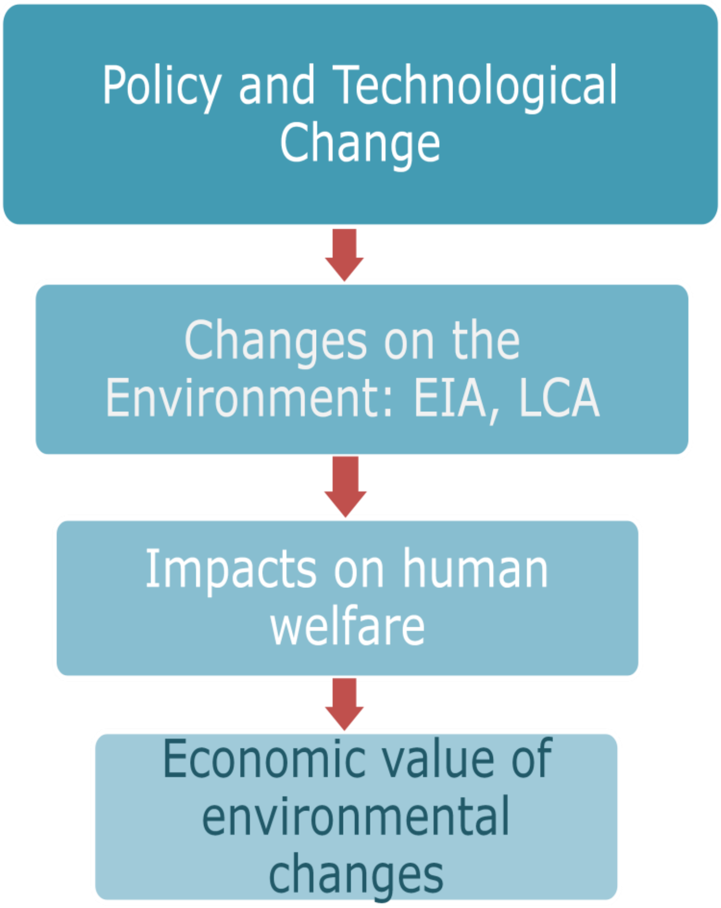

Figure 3 Overview of the impact pathway of policy and technological change

The Total Economic Value (TEV) for any given product or resource is the sum of use (direct, indirect, option value) and non-use values (altruistic, bequest, existence value). Natural resources and their ecosystem services are generally not traded in markets. As a result no market price is available to reflect the economic value of environmental changes. Hence, expressing these impacts in monetary terms using non-market methods is required (see Freeman et al., 2014). We present at the next figure the TEV framework and the economic techniques used in economic valuation of benefits derived from the ecosystem services (see D8.1 for more details).

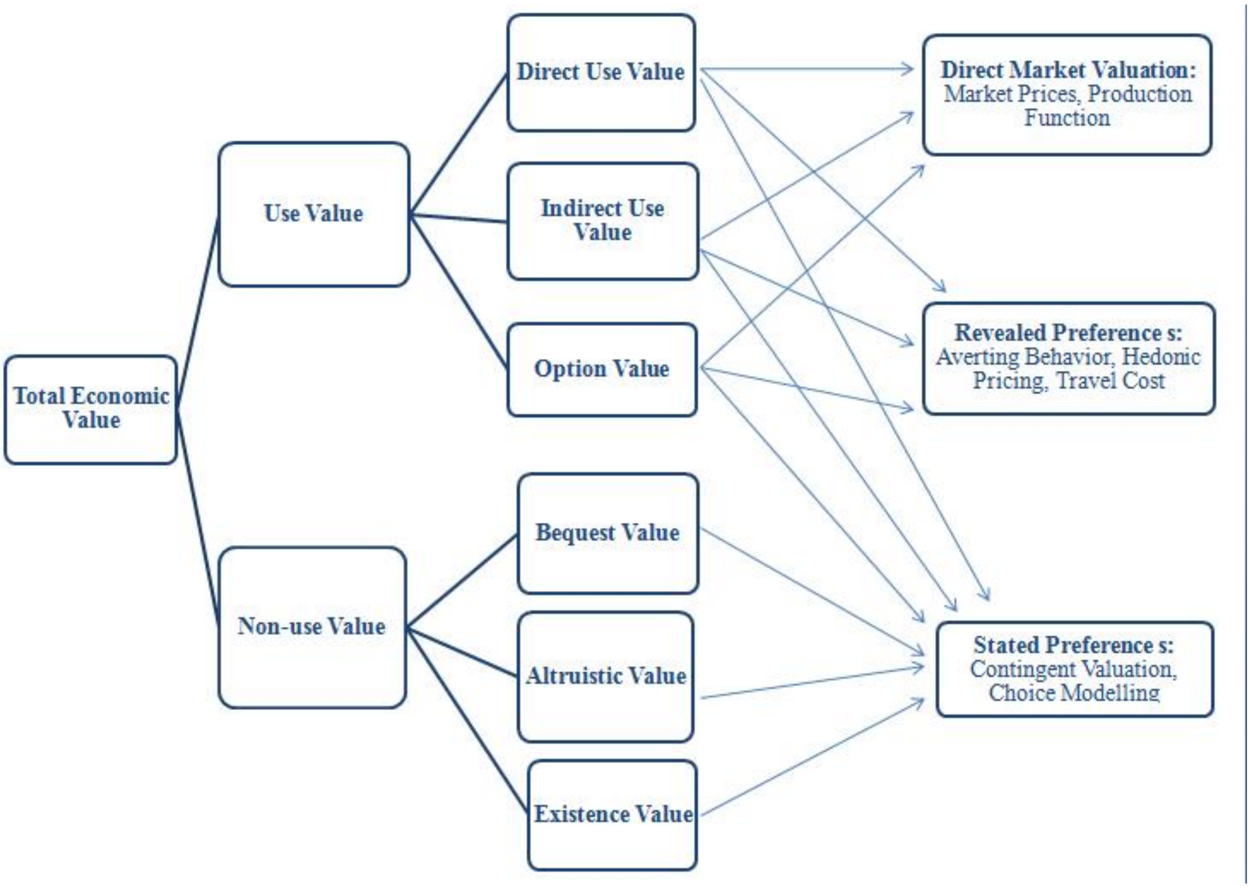

Figure 4 Techniques for monetary valuation of non-market services (Koundouri and Giannouli, 2015)

Primary valuation can be done either using stated preferences or revealed preferences techniques. However, in MERMAID, the benefit transfer method was applied for the socio-economic assessment, i.e. monetary estimates of the non-market value of impacts of MERMAID study sites were derived from earlier studies (Johnston et al., 2015). In addition, based on the Life Cycle Assessment (LCA), we compared each platform's CO_2 emissions to those that would have been produced via traditional (not renewable) energy sources as the result of producing same amount of electricity and aquaculture products. For this case, we used the social cost of carbon (SCC) to estimate the benefits produced from this comparison. After the identification and quantification of the environmental and socio-economic benefits, the financial costs and revenues from energy extraction and aquaculture production were included into the analysis.

More explicitly, MISEA consists of the following steps:

- **Scoping Phase** Defining boundaries, key impacts, key stakeholders, information availability

<u>Socio-economic characterization of the existing situation in the site with regards to wind power production, aquaculture and transport maritime services</u>: The collection of required data for the socio-economic

characterization was performed during the implementation of the regional baseline characterization questionnaire (MERMAID Repository[4]: Regional Profiling Datasets). See section 3.

- **STEP 1** Socio-economic characterization per case study: Wind power, wave power and aquaculture production

Production-Side Analysis of Multi-use Space: This analysis is based on estimated financial costs of offshore structures, and also on the costs of environmental and ecological changes due to the proposed multi-use structure, as identified by the environmental impact assessment.

Demand-Side Analysis of Multi-use Space: This analysis depends on the evaluation of socio-economic consumption benefits related to the proposed structures and also on the benefits of environmental and ecological changes due to the proposed multi-use structure, as identified by the environmental impact assessment/environmental analysis.

- **STEP 2** Translated Externalities into financial flows: Benefit transfer and Life Cycle Assessment (LCA)

Costs and benefits produced by environmental change related to wind power, wave power and aquaculture production were estimated using benefit transfer methods (transferring monetary values from earlier studies to the policy site) and relying on the Life Cycle Assessment with regards to CO_2 emissions quantity change. (See section 4)

- **STEP 3** Recommendations based on economic tools: Social Cost-Benefit Analysis (SCBA)

The last step for assessing viability is the use of Cost Benefit Analysis (i.e. Social Cost Benefit Analysis for MERMAID Project). See section 6.

It should be noted that, a sensitivity analysis was also performed in order to incorporate the socio-economic uncertainty of the environment under which each MUOP design could be developed and operate (See MERMAID D8.6). Particularly, it is assumed that uncertainty about each parameter value can be captured by a probability distribution that will be used to compute the social costs/benefits. A subsequent step in including uncertainty requires experts to provide their estimates of the most likely value of parameters of interest, together with upper and lower bounds, assessing the likelihood that actual values would lay above or below these upper and lower estimates.

Overall, the methodology is used to evaluate the trade-offs with regard to socio-economic welfare between different proposed multi-use structures. Case-study specific recommendations are offered after employing Social Cost Benefit Analysis. See section 7.

[4] http://mermaid.madgik.di.uoa.gr/

2.2 The Assessment Tool

For the purpose of MERMAID MUOPs' assessment, an online assessment tool was developed (See Annex I). This tool incorporates the information produced during the project, comparing the socio-economic aspects derived from the MUOP to the baseline of each case study under consideration. This tool has the potential to be used for future sustainability analysis of multi-use projects.

The importance of this tool lies on its outputs and its capacity to provide a guideline to support decision-making. The MUOP assessment tool was applied in all four case studies and attempts to help all the stages of the research by indicating the pathway of choosing the most appropriate MUOP design with regards to the different aspects involved (socio-economic characteristics, technological, legal, environmental, financial and economic constraints and considerations). The tool helps to identify costs and benefits emerging from the MUOP specific design and thus provides important information for the Social Cost Benefit Analysis (SCBA). The assessment tool collects and systematizes multidisciplinary information for each case study. The different sections of the tool are the following and they are closely related to the MISEA:

A) Technical and Legal Feasibility Assessment;
B) Environmental Impact Assessment;
C) Monetization of Environmental Externalities;
D) Financial and Economic Assessment;
E) Social Cost Benefit Analysis and Risk Analysis

The sections of the assessment tool related to the Mediterranean Site are presented in the Annex I.

A. Technical and Legal Feasibility Assessment

The Technical and Legal Feasibility Assessment (TLFA) section of the assessment tool requires from the users to identify if the MUOP design is feasible by considering legal and technical considerations. Users are also required to take into account financial costs and revenues of the installation and operation of the platform, consider the project's time horizon, any existing possibilities of combined use and finally any other options for technological upgrades. Simultaneously, a set of risks needs to be identified and taken into account. The set of risks include: technical uncertainty, financial uncertainty, impact diffusion (i.e. correlated risks between functions), political uncertainty and unclear definition of property rights.

The users select the appropriate answer which is then quantified accordingly as input into the tool. The first questions represent the main aspects that need to be taken into account for the legal and technical feasibility. The tool quantifies the answers and feeds them into an algorithm that displays a message of whether the user may continue with the rest of the process, or, a message could be shown based on the unmet technical or legal constraints, i.e. if the answers to the last questions are negative.

Table 2 Technical and Legal Feasibility Assessment and Significant Risks

A. Technical and Legal Feasibility Assessment (TLFA)	
a.	Approximations to production parameters (Costs: capital, Operation and Maintenance (O&M), administration costs and revenues)
b.	Definition of project's time horizon
c.	Possibilities of combined use
d	Possibility for technological upgrades
e.	Uncertainty about reliability of the techniques used
f.	Uncertainty about estimates of costs and revenues
g.	Impact diffusion (correlated risks between functions)
h.	Political uncertainty
i.	Unclear definition of property rights
j.	Is location feasible? (Take into account legal considerations)
k.	Is location feasible? (Take into account technical considerations)

B. Environmental Impact Assessment

Regarding the Environmental Impact Assessment (EIA), the users are asked to identify all significantly positive and/or negative environmental impacts (at local, regional and global levels). Also, they are asked if there is an EIA available for similar project(s) in the region. The set of risks identified for this section refer to the uncertainty about climate change and other environmental parameters, the possible non-linear environmental effects, as well as the irreversible environmental effects of the operation of the platforms. The table below presents the questions posed to experts and researchers, including the set of risks to be identified. The answers of the users, which should be based on an Environmental Impact Assessment or Environmental Analysis undertaken during the design phase of the MUOP, are quantified for the tool.

Table 3 Environmental Impacts Assessment and Significant Risks

B. Environmental Impacts Assessment (EIA)	
a.	Significant negative environmental impact (local, regional, global)
b.	Significant positive environmental impact (local, regional, global)
c.	EIA available for similar project in the region
d.	Uncertainty about climate change and other environmental parameters
e.	Non linear environmental effects & threshold identification
f.	Irreversible environmental effects
g.	Environmental considerations: is the location feasible?

C. Monetization of Environmental Externalities

The user is asked to choose the location of the MUOP. According to this choice, pre-estimated monetary values of the identified environmental change related to the specific location are incorporated into the final section of the assessment tool (see Section 4).

D. Financial and Economic Assessment

The Financial and Economic Assessment (FEA) section of the tool attempts to extract the estimated financial costs (capital, operations & management, administrative) of the MUOPs. This section also requires the estimation of potential financial revenues as well as the efficiency gains from combined use of the platform.

The user can upload a csv (comma separated value) formatted file, a format that can easily be exported from all common spreadsheet software such as Microsoft Excel. Alternatively, the user can input manually the requested values at the appropriate input boxes. It should be noted that, the user will be asked to include the number of kWh and kg related to yearly energy production and aquaculture production, respectively. By this way, the corresponding change in CO_2 emissions due to MUOP operation is monetized through the social cost of carbon as an input to the SCBA (see Section 4).

E. Social Cost Benefit Analysis and Risk Analysis

This final section of the tool uses the financial and economic data, including monetized externalities, produced by the previous sections and run a Social Cost Benefit Analysis (SCBA) by comparing discounted flows of costs and benefits. The results indicate if the proposed design is socio-economically sustainable or not. The risks that may influence the results of this assessment concerns the uncertainty and missing information in estimation of external effects and in perception formation as well.

The tool concludes with a risk analysis, simulating different scenarios to define sensitive values and the overall risk of the selected infrastructure.

- First scenario: Deterministic model

The tool uses a number of potentially sensitive variables according to user selection over a predefined list, and calculates net present value for the user specified time horizon. The user chooses the minimum and maximum values for each of the variables. The tool performs sensitivity analysis based on these inputs and produced visualizations so that the user is able to observe the behavior of these variables.

- Second scenario: Stochastic models with one variable fixed.

While one of the potentially sensitive variables of the model (e.g. interest or growth rate) is fixed at the user input value, the tool models the others as randomly distributed according to a predefined distribution. With these parameters the tool runs a Monte Carlo simulation so as to obtain a distribution for the total cost. The results are presented as a summary table with basic statistical values for the distribution of the total cost, and graphic visualizations.

3 The Mediterranean Site Regional Profiling

The suggested sheltered deep water site for a multi-use platform in the Mediterranean area is the Acqua Alta platform, a research platform held by CNR (Centro Nazionale Delle Ricerche). The platform is located in the Northern Adriatic Sea, 16 km off the coastline of Venice, on 16 m of depth. A detailed description of the environmental and biological setting of the region has been provided in previous MERMAID deliverables (MERMAID D7.1) and publications (Airoldi et al 2015, Zanuttigh et al 2015).

The description of the study site profile contributes to a better understanding of the effects of the selected multi-use activities on the local socio-economic environment. This section outlines the socio-economic context of the study site, describes the institutional framework, and identifies actors, i.e. economic sectors, individuals that may be impacted by the MUOP.

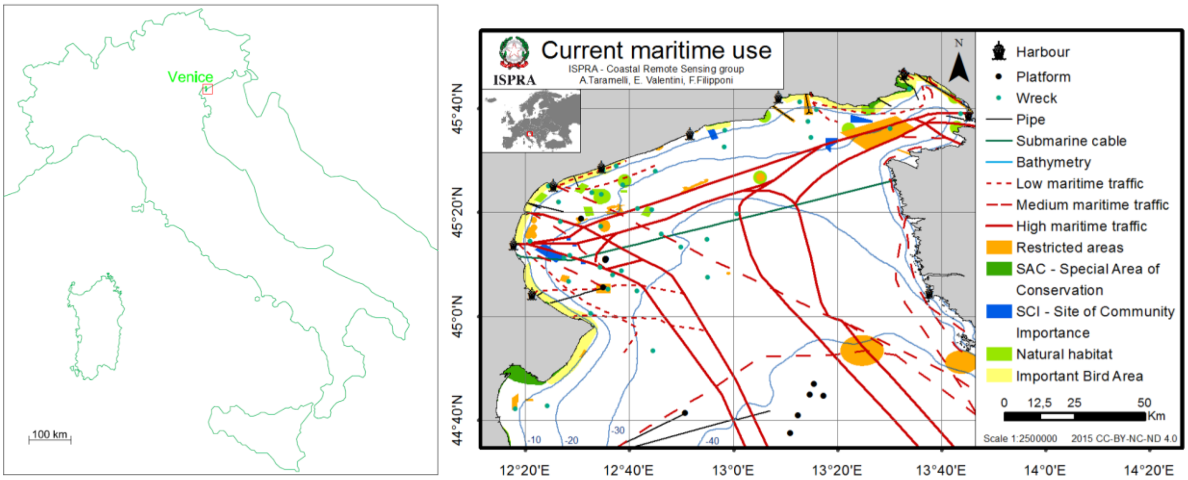

Figure 5 To the left: Location of the site highlighted with a red square to the right: different existing uses in the selected area

3.1 Demographics and Economic Activities

The land area of the study site amounts to18,378 km^2. The population accounts for 4,937,854 inhabitants with population density of 269 inhabitants per km^2 (2011). The population of the study site exhibits a rather balanced distribution between male (51%) and female (49%), while the average household size is around 2.4 persons per household. The qualitative aspects of human resources in the study site can be revealed through the educational level of the population. The population is characterized by a rather favourable educational attainment level, which constitutes an important asset for development prospects. More specifically, almost 46% of the population has accomplished graduate and postgraduate studies.

Total labour in the Mediterranean site amounts to 2,240,713 persons. Male employment amounts to 59%, while female employment accounts for 41%. Unemployment amounts to 128,612 persons (or 5.8%) of which 46% is male and 54% is female. Sectoral employment is often considered a crucial indicator in analysing economic structure and organization. The analysis of employment by branch of economic activity portrays that the major sectors offering employment in the region are the manufacturing sector (28%) and the trade sector (15%). The economy is more services oriented since tertiary sector accounts for 60% of total employment, while the secondary sector contributes by 37%. The contribution of agriculture to total employment has been contracted to 3%. With regards to the qualitative characteristics of the employees, almost half of them hold baccalaureate, while 15% of labour force has attained graduate and postgraduate studies. The percent of employees with primary education is only 4%.

The total value of regional production in the study site amounts to 130,634 million euros (2011). In terms of the sectoral shares of regional production, the tertiary sector contributes around 63% to the regional product generation, the secondary sector contributes by 35%, and the primary sector by only 2%. More specifically, the manufacturing industry contributes by 26% in the regional product formation, the property and business services sector by 14%, and the trade sector by 12%.

3.2 Socio-economic Impacts of MUOP

A thorough examination of the current political and social conditions in the Mediterranean site revealed that in terms of the aquaculture the most vulnerable groups and those impacted more are fishermen, persons involved on activities related to tourism and transport constructing and storage. With regards to wave energy production, the most vulnerable groups are mainly energy suppliers, the sector of equipment and machinery, the transport constructing activities and the consumers.

Since there are no current operations for MUOPs, it has been estimated that aquaculture will create 17 new jobs, i.e. 10 jobs on fish farming, 5 jobs on tourism related activities and 2 jobs on transport constructing and storage. Similarly, the direct employment effects of the wave energy production are 18 new jobs including 10 jobs on energy suppliers, 5 jobs on the equipment and machinery sector and 3 jobs on other professional and transport constructing activities. The involved stakeholders who may be affected by the MUOP are located in the coastal areas in Regione Veneto. It should be noted that in the final design, no wave energy converters are considered. Nevertheless, information with regards to wave energy production is included in regional profiling for reference to future projects.

3.3 Institutional and Policy Framework

The Regional Government which is in charge of authorizing aquaculture activities can reimburse up to 50% of investment expenditures. State refunds up to 80% of insurance premium in order to create incentives for insurance that cover structural risks linked to natural events, climatic conditions and price fluctuations. Furthermore, consulting local commissions have been set up by the Region for the modernisation of the aquaculture sector.

It has to be stressed that aquaculture in the EU is regulated by strict laws. In order for a fish farm to get a permit of operation, it needs to fulfill an extensive list of requirements, which ensure that the operation will not have adverse impacts on the environment and that the site where it will operate is suitable for this type of productive activity and there is no clash with other activities. Once a permit is issued, which means an EIA has been conducted in the area and all other requirements are met, then the company is obliged to conduct regular checks/tests/analyses, which ensure the proper operation of the farm.

There are no regional and national legislation specifically addressed to wave energy projects. The Ministry of Environment has an important role with respect to environmental issues and the Ministry of Infrastructures and Transports with respect to the production of energy. The authorizations for the construction and operation of wind plants are issued by the Ministry of Infrastructures and Transports. Consultations are also made with the Ministry of Economic Development and the Ministry of the Environment, while the peripheral offices of Genio Civile provide concessions of the maritime State property use. With regards to incentives for energy from marine renewable sources, the government ensures 0.34 € per kWh for all plants smaller than 5 MW. As for subsidies, there is no national or regional legislation. Unlike other energy sectors, wave energy generation is in an early stage of development and there is no established industry consensus on codes and standards.

3.4 Controversies, Uncertainty and Implementation Obstacles

Controversies about aquaculture have arisen when clam producers imported a Philippine species (larger and with quicker growth compared to the native clam). This was intentionally introduced in Northern Adriatic Sea coastal lagoons for aquaculture purposes in 1983 to support a clam fishery suffering a crisis due to overexploitation of native clam *Tapes decussatus*.The Japanese kelp *Sargassummuticum*, the Asian kelp *Undariapinnatifida* and the pacific oyster *Crassostreagigas* have also been introduced by aquaculture and have rapidly spread in Venice and Po Delta coastal lagoons. As a result, concerns about the impacts of aquaculture on biodiversity and the current fishery sector were expressed.

In regard to potential nutrient loads deriving from aquaculture, Karakassis et al (2005) estimated that the overall N and P waste from fish farms in the Mediterranean represents less than 5% of the total annual anthropogenic discharge, while the overall annual increase in P and N pools in the Mediterranean, under a production rate of 150000 tons, is less than 0.01%. In other words, Karakassis et al (2005) results imply that “there is little risk of a noticeable increase in the nutrient concentration in the entire Mediterranean or even in the Eastern Basin as a result of fish farming”. Moreover, Pitta et al (2009) found that grazing plays a key role in regulating phytoplankton biomass, keeping chla at very low levels and effectively transferring nutrients up the food web. Nonetheless, it is essential to tackle water eutrophication from fish feeding, preserve today diving and favour future diving activities in 3.5 to 8 miles. An alternative to the off-shore port of Venice could be future ship routes to Trieste. The selected site faces the risk of eutrophication and hence, the alternative ship routes to Trieste are indeed considered.

In addition, the selected study site minimized the controversies about energy production with regards to potential conflicts with other relevant environmental characteristics or uses of the marine environments, e.g., off-shore ports, naturalistic areas, fishery activities, tourism activities, and with the general conservation of the ecologically relevant species and habitats (see MERMAID Location Selection Tool).

Furthermore, fishery is a main income source in the region in both commercial and recreational terms. Significantly valuable biological seabed concretions (coralligenous type), which are called tegnue, exist in the region; these are protected areas and attract lots of divers. Thus, the selection of the location of the MUOP was done specifically excluding those areas. However, the local stakeholders are very skeptical about the economic feasibility and successes of aquaculture, while on the contrary are very optimistic for the economic potential of the wave energy production.

4 Monetization of Environmental Externalities

From the previous section it is concluded that due to the multidimensional character of the impacts (socio-economic and environmental of direct and indirect outcomes, i.e. at stakeholder, industry and community scale), a range of different information was needed in order to assess them. As a result, market data, secondary data for the performance of simulations, surveybased primary data, data provided from literature review, consultation with experts and stakeholders and information coming from environmental impact assessments were important in the framework of integrated environmental and socio-economic assessment.

The construction of multi-use offshore platforms might cause a variety of different changes to the environment and humans. The modification of the natural environment, i.e. the replacement of natural substrata with harder surfaces of stone, concrete, asphalt, metal or other artificial material can enhance the distribution of a number of species typical of hard substrata, some of which can thrive on these anthropogenic surfaces. Because of this, marine infrastructures are sometimes perceived as an opportunity for habitat enhancement, providing local benefits associated to hard substrata where none previously existed, or potential refuge for rare or threatened native rocky species (Inger et al., 2009; Martins et al., 2010; Sheehy and Vik, 2010; Langhamer, 2012;Perkol-Finkel et al., 2012). Also, there is evidence that marine infrastructures can offer particularly favourable substrata to many non-indigenous species (NIS) (Bulleri et al 2006, Airoldi et al 2015). NIS may colonize from nearby natural rocky habitats or could spread out of ports, harbors, marinas, or other sources of introduction, especially when multiple artificial structures are built relatively close to one another. Furthermore, offshore structures provide some degree of refuge from trawling activities since for safety reasons it is forbidden to navigate closer than a distance of between 200m and 1000m from offshore platforms. This could be really effective at the North Adriatic Sea, where commercial trawling is intensive. On the other hand, marine infrastructures can affect seriously the genetic and species diversity (Fauvelot et al 2009, 2012), the biological resources and the water quality because of the high levels of disturbance in the marine environment (Airoldi & Bulleri

2011). Impact from feeding fish should be taken into account, as well as other disturbances produced by the possible increased noise, light and electromagnetic fields.

Unregulated aquaculture activities may include increase in organic matter contents and compositional changes of the sediment below fish cages, alteration of inorganic and organic chemistry of farm water and sediments, alteration of abundance, biomass and biodiversity of micro, meio- and macrobenthic communities and modification of distributional patterns of phyto- and zooplankton abundance and production. However, the European rules and directives ensure the sustainable operation of aquaculture without harming the environment. The maintenance of the technical equipment is also necessary for ensuring that the waste would be as little as possible. If these actions are not taken, then the flora and the fauna of the area could be affected irreversibly.

Furthermore, artificial structures can harbour polyps of cnidarians and dinoflagellates. When this happens, they may lead to increase numbers of, for example jellyfish (Duarte et al. 2013) or harmful algal blooms (Villareal et al. 2007) or damage fish if the polyps are attached to fishcages (Baxter et al. 2012). In addition, according to EU (biodiversity.europa.eu), invasive species can cause great damage to native species by competing with them for food, eating them, spreading diseases, causing genetic changes and disrupting various aspects of the food web and the physical environment.

Within MERMAID we have shown that on artificial structures non indigenous species (NIS) may have an advantage over natives, leading to regional scale changes in their relative abundances (Airoldi et al 2015). However efforts have been made to identify solutions to reduce some of these risks. For example, the settlement and growth of NIS on artificial structures can be limited by using materials or coatings that prevent settlement of fouling, by favouring the design of fixed surfaces rather than floating ones by favouring the colonisation by native species, and by minimizing disturbances. Ecologically informed repair schedules can limit the spread of non-indigenous species by favouring a quicker recovery of the native ones (Airoldi & Bulleri 2011). In the Adriatic sea, work within MERMAID has also been done to actively garden ecologically relevant habitat forming species, to contemporaneously enhance native species and deter non-indigenous ones (Perkol-Finkel *et al.*, 2012, Ferrario et al 2015).

Table 4 Ecosystem Services Potentially Affected by the MUOP

Mediterranean Site				
Category of Ecosystem Services	Provisioning Services	Supporting/Regulating Services	Cultural Services	Habitat Services
Ecosystem Services	Food and Raw Materials	Nutrient Cycling: Harmful Algal Blooms	Cognitive Development	Diversity
Comments	Operation Phase	Construction and Operation Phase	Not relevant	Construction and Operation Phase

Source: Communication with Site Managers and Biologists

4.1 Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique that was developed for assessing environmental impacts of a product/service considering all of the life stages of them which is also named as cradle-to-grave analysis due to this aspect (Baumann & Tillman, 2004). For providing a common application of LCA studies, ISO published ISO 14040 series standards (ISO, 2006a, b). According to these documents, an LCA study should pass four main stages as Goal & Scope Definition, Inventory Analysis, Impact Assessment and Interpretation, respectively. LCA is an iterative process which may be repeated and developed by going deep into the detailed of the system analysed. A Life Cycle Analysis (LCA) study was carried out to obtain a quantitative evaluation of environmental impacts of designed MUOP for the Mediterranean site.

Multi-use offshore platform designed for Mediterranean Sea consists of 4 wind turbines and a fish farm. Wind turbines are 3.3MW Vestas turbines and the total electricity generation is expected to be 20 GWh per year. In 2006 Vestas published Life Cycle Assessment of offshore and onshore wind farms consist of 3.0 MW wind turbines. According to this report "1 kWh electricity generated by a V90-3.0 MW offshore turbine has an impact of 5.23 grams of CO_2 during the life cycle" (Vestas, 2006), this result is substitutable for current wind farm. When this value is compared to usage of coal for electricity production (799.6g CO_2-eq, Schlömer et al., 2014), amount of produced CO_2eq gases is lower with a difference of 794.37 gCO_2-eq for 1kWh electricity production. If the comparison is made according to European electricity mix (ENTSO-E network) which corresponds to 462 g CO_2-eq/kWh (Itten et al., 2014), the gain of environmental burden in the terms of CO_2-eq is 456.77g/kWh.

In the context of the LCA study made for Mediterranean site, an LCA in line with ISO 14040 and 14044 standards is carried out for aquaculture function of MUOPs using Ecoinvent integrated GaBi software. CML 2001 method was the calculation method for characterization of environmental impacts of the study. CML 2001 method evaluates the potential environmental impacts in 11 different categories: Global warming potential (GWP), acidification, eutrophication, ozone layer depletion, abiotic depletion, abiotic depletion fossil, freshwater aquatic ecotoxicity, marine aquatic toxicity, human toxicity, terresticecotoxicity and photochemical ozone creation.

Furthermore, the LCA determined the potential environmental burdens of fish farms through their life cycles. In the system studied, production and installation of structures, operation and maintenance activities, and disposal of structures as well as transportation of materials during the life cycles were considered. In this study, fry production is excluded. Functional unit was selected as one ton of harvested fish. Required data for LCA study was provided from Kefalonia Fisheries via the prepared questionnaire and personal communication with Yukiko Krontira. In the fish farm European seabass (*Dicentrarchuslabrax*)andgilthead seabream (*Sparusaurata)* is planned to be farmed and the capacity of the farm is 2000 tons per year. The results show that for each ton of harvested fish, 2.41 tons of CO_2-eq will be emitted during the life cycle stages of the fish farm.

Table 5 Unit amount of CO_2 emissions per function of MUOP and the compared production technologies

Function	Parameter	Amount	Unit
MUOP Electricity Production	Amount of CO_2-eq production per 1 kWh	**5.23**	g CO_2-eq
Coal Based Electricity Production	Amount of CO_2-eq saved through MUOP electricity production per 1 kWh	**794.37**	g CO_2-eq
ENTSO-E Electricity Production	Amount of CO_2-eq saved through MUOP electricity production per 1 kWh	**456.77**	g CO_2-eq
Fish Production	Total amount of CO_2-eq production per 1t	**2.41**	t CO_2-eq

Table 6 Total amount of CO_2 emissions per function of MUOP and the compared production technologies

Function	Parameter	Amount
MUOP Electricity Production	Amount of CO_2-eq production (assuming 20 GWh/year)	5.23gCO_2-eq/kWh *20GWh/year*20years =2092 ton CO_2-eq
Coal Based electricity Production	Amount of CO_2-eq saved (assuming 20 GWh/year)	794.37gCO_2-eq/kWh *20 GWh/year*20years =317748 ton CO_2-eq
ENTSO-E Electricity Production	Amount of CO_2-eq saved (assuming 20 GWh/year)	456.77 gCO_2-eq/kWh *20GWh/year*20years =182708 ton CO_2-eq
Fish Production	Total amount of CO_2-eq production (assuming 2000 t/year)	2.41tCO_2-eq*2000t/year*30 =144000 ton CO_2-eq

Based on the Life Cycle Assessment the economic benefit of changes in CO2 emissions due to MUOP construction and operation was estimated. For this purpose, the social cost of carbon was used, which refers to the monetary value, the shadow price of world-wide damage done by anthropogenic CO2 emissions (Pearce 2003). According to Arrow et al (2014) social cost of carbon is $19.50 per ton of carbon using the random walk model in Newell and Pizer (2003), $27.00 per ton using the state-space model in Groom et al. (2007), and $26.10 per ton using the preferred model in Freeman et al. (2013). The value used was the one produced using the state-space model **(22.5€ per ton[5], 2013)**.

[5] Exchange rate 0.83 $/ €

4.2 Benefit Transfer

Gathering primary site-specific data is costly and time-consuming, which has made Benefit Transfer (BT) a popular alternative for the valuation of ecosystem goods and services. BT uses existing economic value estimates from one location to another similar site in another location. In particular, it concerns an “application of values and other information from a ‘study’ site where data are collected to a ‘policy’ site with little or no data” (Rosenberger and Loomis, 2000, p.1097). That is the result of previous environmental valuation studies are applied to new policy or decision-making contexts. However, there are a number of criteria that have been identified in the literature for benefits transfer to result in reliable estimates as summarised in Brouwer (2000):

- sufficient good quality data
- similar populations of beneficiaries
- similar environmental goods and services
- similar sites where these goods and services are found
- similar market constructs - similar market size (number of beneficiaries)
- similar number and quality of substitute sites where the environmental goods and services are found.

Bergland et al. (1995) discussed three main approaches to BT: (i) the transfer of the mean household WTP, (ii) the transfer of an adjusted mean household WTP and, (iii) the transfer of the demand function. The first approach assumes similarity in good and socio-economic characteristics between the study and target site and the other two approaches attempt to adjust the mean WTP and re-calculate it respectively, in order to account for differences between the two sites in terms of environmental characteristics and/or socio-economic characteristics. See also recent BT reviews such as Navrud (2010), Johnston and Rosenberger (2010), and Johnston et al. (2015).

It was decided under MERMAID to apply an adjusted BT to account for potential environmental and socio-economic impacts. In order to choose the relevant studies, common socio-economic and geographical characteristics are considered between the policy site and the study sites of each examined paper. Since it is hard to find studies related to offshore multi-use platforms, research has to be expanded on case studies that include similar environmental and social effects in the marine area without explicitly referred to offshore platforms. The aim is to estimate the effects produced - moving from the baseline to the final platform design - on the ecosystem services defined under the environmental assessment.

Based on the policy site characteristics and the information provided by the site manager and biologists, it was decided to estimate the economic value of the negative effects of the presence of Harmful Algal Blooms in Italian waters from the construction of MUOPs. Although such effects are currently rather small, they could be further enhanced by water quality issues related to aquaculture and by the introductions of additional artificial habitats. However, since these effects will not be crucial in the first 30 years of operation and the location of the MUOP was chosen with the scope to minimize such negative environmental effects, it was chosen not to consider this value to the social cost benefit analysis.

5 Financial and Economic assessment

The Mediterranean site's MUOP (wind-fish farm) requires 44 million euros for the establishment of the wind farm and it is expected to produce 1 million euros per year for 20GWh per year for the energy extraction. However, no more information is available. Hence, it was not possible to run the social cost benefit analysis for this function.

On the other hand capital expenditure for the establishment of the fish farm, over the 22 year period is estimated to be 3.7 million euros, of which 3.5 M € is required over the first 7 years, where the fish farm reaches its optimum operational capacity. At year 7 revenues from the sales of the fish produced are expected at 14.7 M€ (at an operating expenditure of 12.5 M €). Given the current market status (prices, days payable/receivable etc) the total fish farming investment is estimated at 18.8 M € and is expected to break even at year 13.At year 22, revenues from sales reach 19.9 M €, yielding an EBITDA of 4.1 M€ and EAT of 3.3 M €. The Net Present Value (NPV) of the fish farm investment is estimated at 7.2M € (over the 22 year period, at a discount rate of 6 %). Data for fish production (production rates, production costs etc) is produced by a production model developed in Kefalonia Fisheries. Other assumptions used for calculating prices and revenues (discount rates etc) are based on mean values that are currently true for the market.

Table 7 Cost categories of an on-growing site

Cost of Juveniles	This cost category varies depending on the size of the juveniles at the time they are transferred to the sea and whether it is fish fry grown on the fish farm's hatchery or purchased fry from a supplier
Cost of feed	This cost category is the most important in fish farming of the specific species (carnivorous species and feeds must contain substantial amounts of fish meal and fish oil)
Cost of labor (Depending on the size of the fish farm, number of staff changes. Staff is occupied with daily operations & maintenance work)	• Production manager • Workers/Feeders • Divers • Captain/seamen
Energy cost (energy consumption related to the cage farm operations)	• Fuel for the vessels (transportation of feeds from the onshore silo to the cages, use of the vessel for feeding and inspection of cage condition etc) • Energy required for the operation of air compressors used for supplying automatic feeders with feed • Energy required for the operation of air compressors used for filling divers' oxygen tanks • Operation of the crane (for harvesting and changing the nets) • Lighting • Other energy needs (plugs for electrical devices)

Other consumables	• Medicines- any kind of necessity for medical treatment of fish stock (either precautionary vaccinations or treatment of a disease outbreak) • Nets
Insurance-Rent-Maintenance	• Insurance • Rent • Maintenance costs- for equipment, cages, nets, vessels, structures
3rd party fees and Services	• Veterinary, legal and other fees • Maintenance etc services in case of repairs which cannot be performed by staff
Administrative Expenses	• Unit manager • Secretary • Rent • Other expenses- travel, electricity, water, telephone
Sales Expenses	• Sales costs- cost of operation of the sales' department • Transport & repackaging- cost of transport of the goods to the client and intermediate repackaging
Packaging	• Packaging consumables- polystyrene boxes, plastic sheets, stretch film, straps, labels etc • Labor-packaging unit staff • Energy-room cooling, sorting machine, ice machine, scales, computers etc • Other consumables

Source: KEFALONIA Fisheries

6 Social Cost Benefit Analysis

The Social Cost Benefit Analysis (SCBA) assesses the monetary social costs and benefits of an investment project over a time period in comparison to a well-defined baseline (reference) alternative. In this way the costs and benefits of MUOPs are evaluated and compared to estimate the economic efficiency of implementing the project. As a rule, a project is deemed to be socially profitable if total discounted benefits exceed total discounted costs (positive net present value (NPV)). The NPV results reveal whether the net benefit generated by the investment project of Multi-Use platforms is positive and significant well into the future, conditional on the utilized discount rate scheme. A general calculation of the NPV is the following:

$$NPV = -\sum_{t=0}^{N} \frac{K_t}{(1+r)^t} + \sum_{t=0}^{N} \frac{B_t - C_t}{(1+r)^t}$$

Where Kt is the construction cost, Bt is the stream of benefits, Ct is the stream of operation and maintenance costs and r is the discount rate. Monetized values of externalities are also included in the benefits or costs terms.

Furthermore, the Internal Rate of Return (IRR) has been estimated. IRR is the discount rate that makes the NPV equal to zero. The higher a projects IRR, the more desirable is to undertake the project. Any project with an IRR greater than the discount rate used for the project is a profitable one.

For the Mediterranean site the financial costs and revenues, together with the costs derived by the CO_2 emissions produced due to fishing operation were included in the SCBA. Benefits derived from the reduction of CO_2 emissions were not included in the SCBA, since due to lack of information only the single-use scenario was examined. The estimated time horizon in the SCBA was 22 years.

Triangular distribution was used in fish investment and fish revenue. In the absence of any information regarding the stochastic factors affecting wind investment, the triangular distribution was considered as a reasonable assumption, with central value the given investment cost and boundaries at $\pm$ 15% of the central value.

Normal distribution was used in: fish labor, raw material, other, maintenance, operating costs and energy output. Since there was no information about the specific distributions and only a central value for each of the items was available, a normal distribution with mean the given central value was considered. The structure of the normal distribution was determined such that the mass included in the interval of $\pm$ two standard deviation from the mean has boundaries at a distance of $\pm\gamma$ % of the mean the choice of γ was consistent with the data of the specific case. That is $\mu \pm 2\sigma = \mu \pm \gamma\mu$.

Two alternative values of 3% and 4% were used for the discount rate. These values are consistent with values obtained from the Ramsey formula for the long lived projects: $r = \rho + \eta \cdot g$

- where $\rho = L + \delta$, is the rate at which individuals discount future consumption over present consumption
- Catastrophe risk (L): catastrophe risk is the likelihood that there will be some event so devastating that all returns from policies, programs or projects are eliminated, or at least radically and unpredictably altered.
- Pure time preference (δ): pure time preference, reflects individuals' preference for consumption now, rather than later, with an unchanging level of consumption per capita over time.
- Annual growth in per capita consumption (g)
- Elasticity of marginal utility of consumption (η)

Finally, the Monte Carlo simulations involved 1000 repetitions. Risk analysis results are presented in deliverable 8.6. The results of the SCBA are summarized in the table below.

Table 8 Net Present Value and Internal Rate of Return estimations for fish production

	mean NPV(3%)	st.dev NPV(3%)	mean NPV(4%)	st.dev NPV(4%)	mean IRR	st.dev IRR
Single-use: Fish production	16,052,583.76	6,179,906.34	12,140,351.31	5,589,853.89	8.91%	2.35%

The estimates of mean NPV and its standard deviation suggest that the fish production scenario passes the CBA test both in terms of NPV (positive NPV) and IRR (IRR greater than the discount rate) under all alternative assumptions regarding the discount rate and costs related to the production of CO_2 emissions.

7 Discussion and Recommendations

There are no detailed data on financial costs and returns or on environmental, social and economic impacts for each single activity or all activities combined as suggested by the final design for the Mediterranean case study. However, all preliminary, although tentative, analyses lead to the same conclusion. In the short term, going offshore is not sustainable. In the long-run, coastal and marine spaces might become more limited, and then going offshore will become more important to avoid unplanned and crowded uses in the future. More explicitly, for the case of aquaculture, going offshore provides better health of farmed fish, since it is supposed to provide better water quality to the farmed fish, lessen the possibility of infectious agents being transferred to them and provide a water current regime that will promote better renewal of water and waste dispersal.

Indeed, in the Mediterranean case study, the internal rate of return for *all activities combined* is likely to be negative, if based on financial analysis, and it is likely to be positive but very small, if based on economic analysis, where social and environmental impacts are taken into account. In other words, from a current private and public perspective, there is no reason to build a MUOP platform. However, from a future public point of view, where future benefits are considered, it may be wise to move offshore some fish and energy activities.

This decision is likely to be opposed by current stakeholders for two main reasons: a) they might be expected to bear costs today for benefits arising (for others) tomorrow: think of larger fuel costs to reach an activity offshore or the larger risk to implement an activity offshore; b) they might not perceive the obtained benefits today: think of the reduced environmental impacts. A similar context was observed in urban land use planning in Italy in the 1950s, where many activities such as carpenter's or smith's shops were inside villages, with benefits in terms of time, security, but costs in terms of noise, pollution, which were then moved to dedicated areas in the 1970-1980s.

A subsidisation of offshore activities could solve the first concern (i.e. current private costs are turned into current public costs), whereas information campaign on environmental benefits could solve the second concern (i.e. current private benefits are highlighted). In other words, while private decision-makers are unlikely to perceive future benefits from moving offshore, by emphasising current costs only, public decision makers could impose an inter-generational distribution of costs and benefits, provided that the estimated future benefits are large enough.

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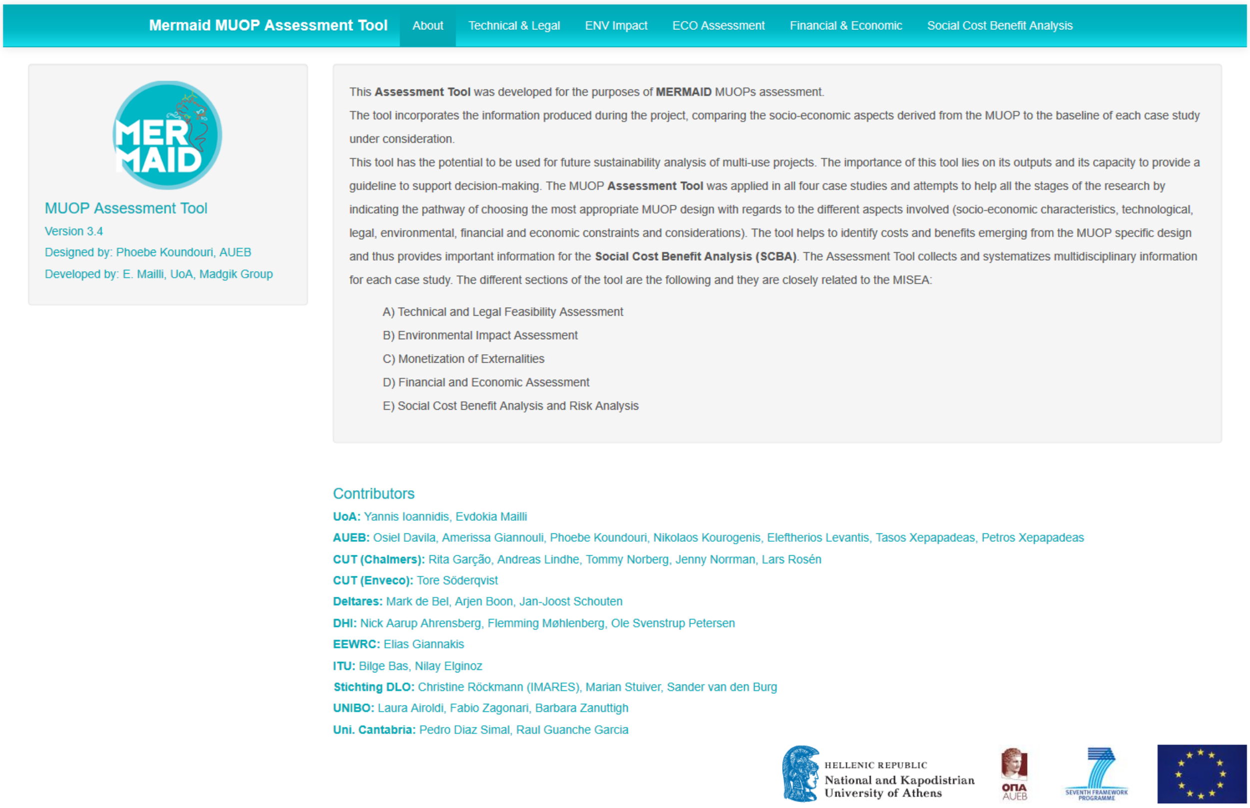
Annex I The Assessment Tool



Mermaid MUOP Assessment Tool | About | Technical & Legal | ENV Impact | ECO Assessment | Financial & Economic | Social Cost Benefit Analysis

MUOP Assessment Tool
Version 3.4
Designed by: Phoebe Koundouri, AUEB
Developed by: E. Mailli, UoA, Madgik Group

This **Assessment Tool** was developed for the purposes of **MERMAID** MUOPs assessment.

The tool incorporates the information produced during the project, comparing the socio-economic aspects derived from the MUOP to the baseline of each case study under consideration.

This tool has the potential to be used for future sustainability analysis of multi-use projects. The importance of this tool lies on its outputs and its capacity to provide a guideline to support decision-making. The MUOP **Assessment Tool** was applied in all four case studies and attempts to help all the stages of the research by indicating the pathway of choosing the most appropriate MUOP design with regards to the different aspects involved (socio-economic characteristics, technological, legal, environmental, financial and economic constraints and considerations). The tool helps to identify costs and benefits emerging from the MUOP specific design and thus provides important information for the **Social Cost Benefit Analysis (SCBA)**. The Assessment Tool collects and systematizes multidisciplinary information for each case study. The different sections of the tool are the following and they are closely related to the MISEA:

A) Technical and Legal Feasibility Assessment
B) Environmental Impact Assessment
C) Monetization of Externalities
D) Financial and Economic Assessment
E) Social Cost Benefit Analysis and Risk Analysis

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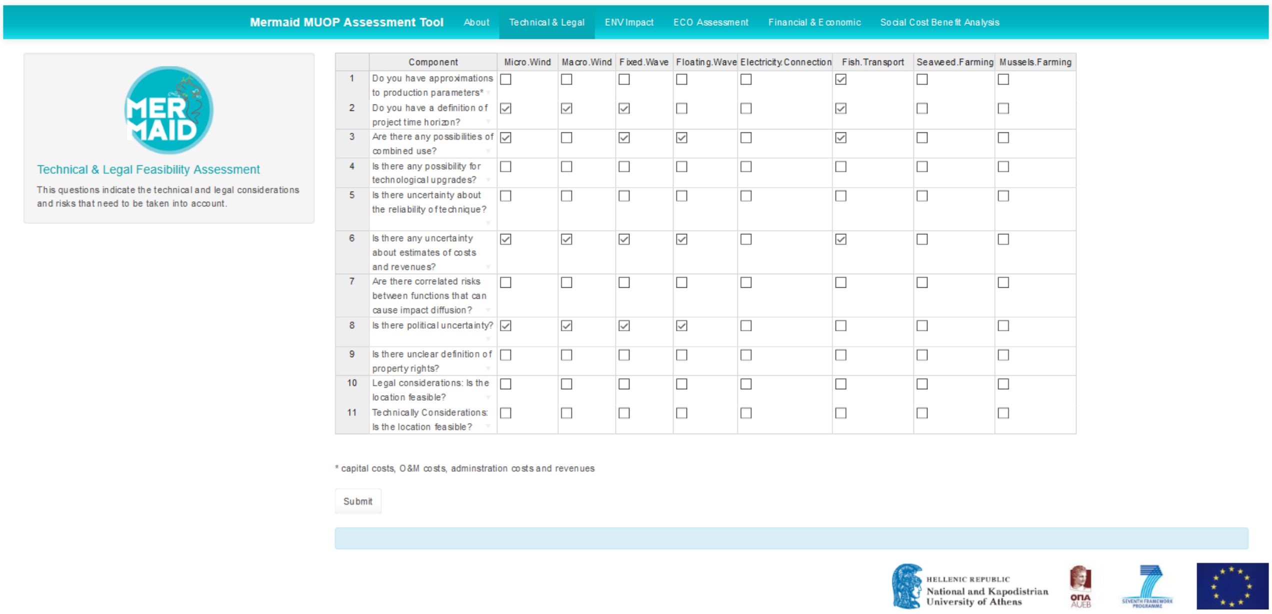
Techinal and Legal Feasibility Assessment



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Technical & Legal Feasibility Assessment
This questions indicate the technical and legal considerations and risks that need to be taken into account.

	Component	Micro.Wind	Macro.Wind	Fixed.Wave	Floating.Wave	Electricity.Connection	Fish.Transport	Seaweed.Farming	Mussels.Farming
1	Do you have approximations to production parameters*	☐	☐	☐	☐	☐	☑	☐	☐
2	Do you have a definition of project time horizon?	☑	☑	☑	☐	☐	☑	☐	☐
3	Are there any possibilities of combined use?	☑	☐	☑	☑	☐	☑	☐	☐
4	Is there any possibility for technological upgrades?	☐	☐	☐	☐	☐	☐	☐	☐
5	Is there uncertainty about the reliability of technique?	☐	☐	☐	☐	☐	☐	☐	☐
6	Is there any uncertainty about estimates of costs and revenues?	☑	☑	☑	☑	☐	☑	☐	☐
7	Are there correlated risks between functions that can cause impact diffusion?	☐	☐	☐	☐	☐	☐	☐	☐
8	Is there political uncertainty?	☑	☑	☑	☑	☐	☐	☐	☐
9	Is there unclear definition of property rights?	☐	☐	☐	☐	☐	☐	☐	☐
10	Legal considerations: Is the location feasible?	☐	☐	☐	☐	☐	☐	☐	☐
11	Technically Considerations: Is the location feasible?	☐	☐	☐	☐	☐	☐	☐	☐

* capital costs, O&M costs, adminstration costs and revenues

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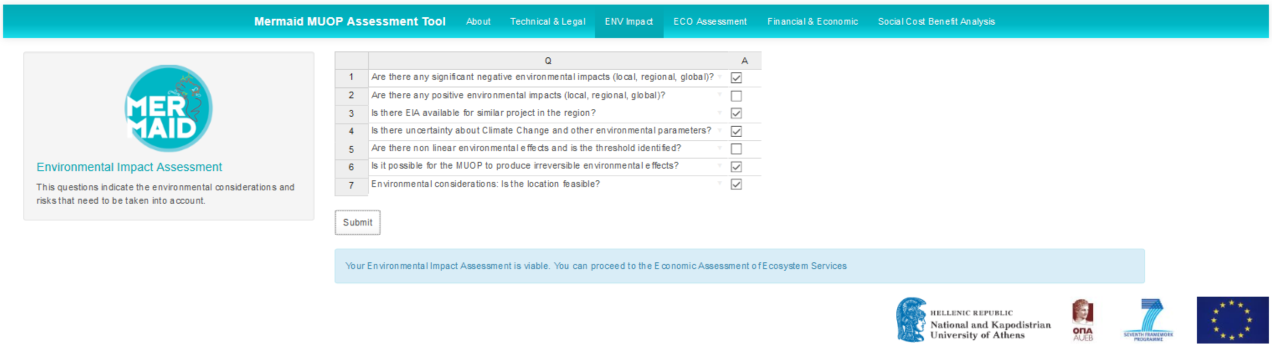
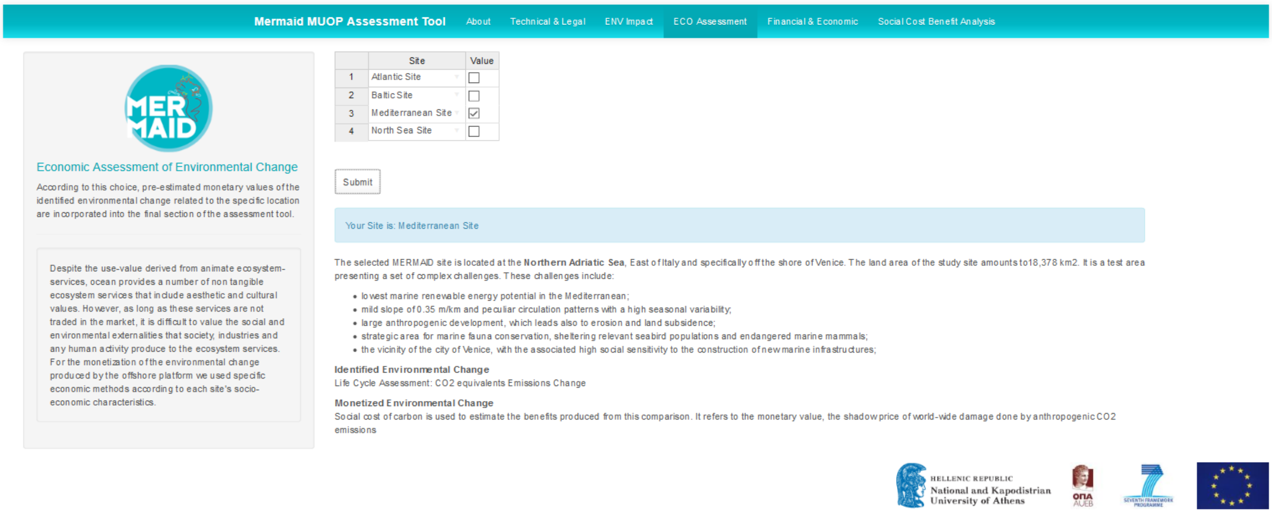
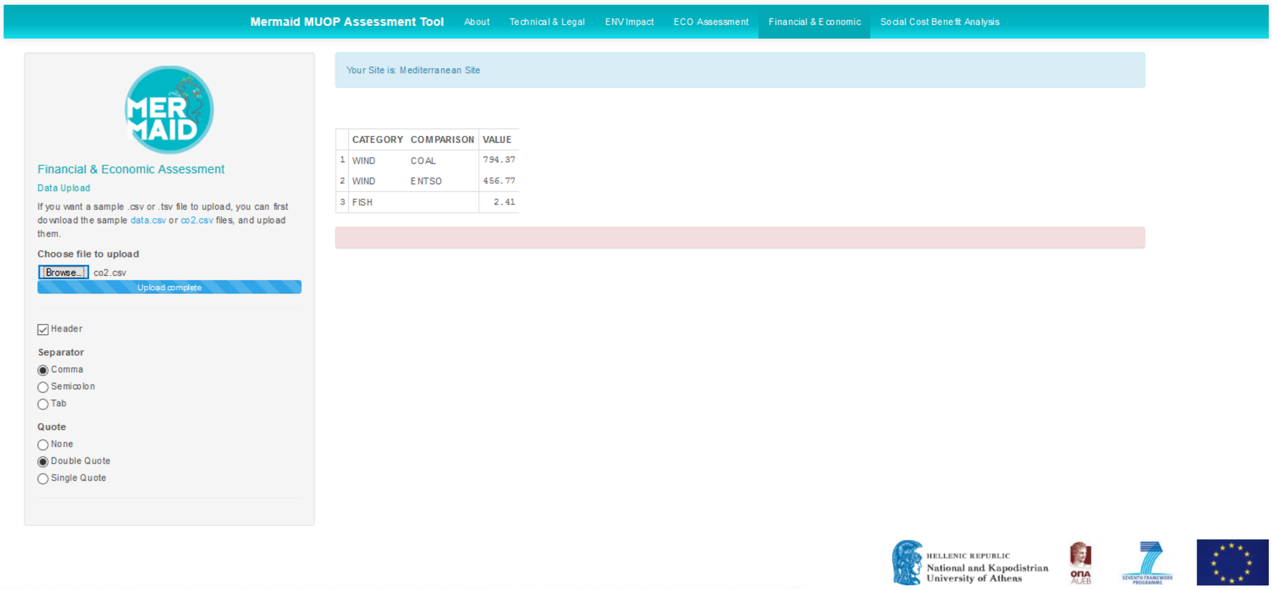
Environmental Impact Assessment



Monetization of Environmental Externalities



Financial and Economic Assessment



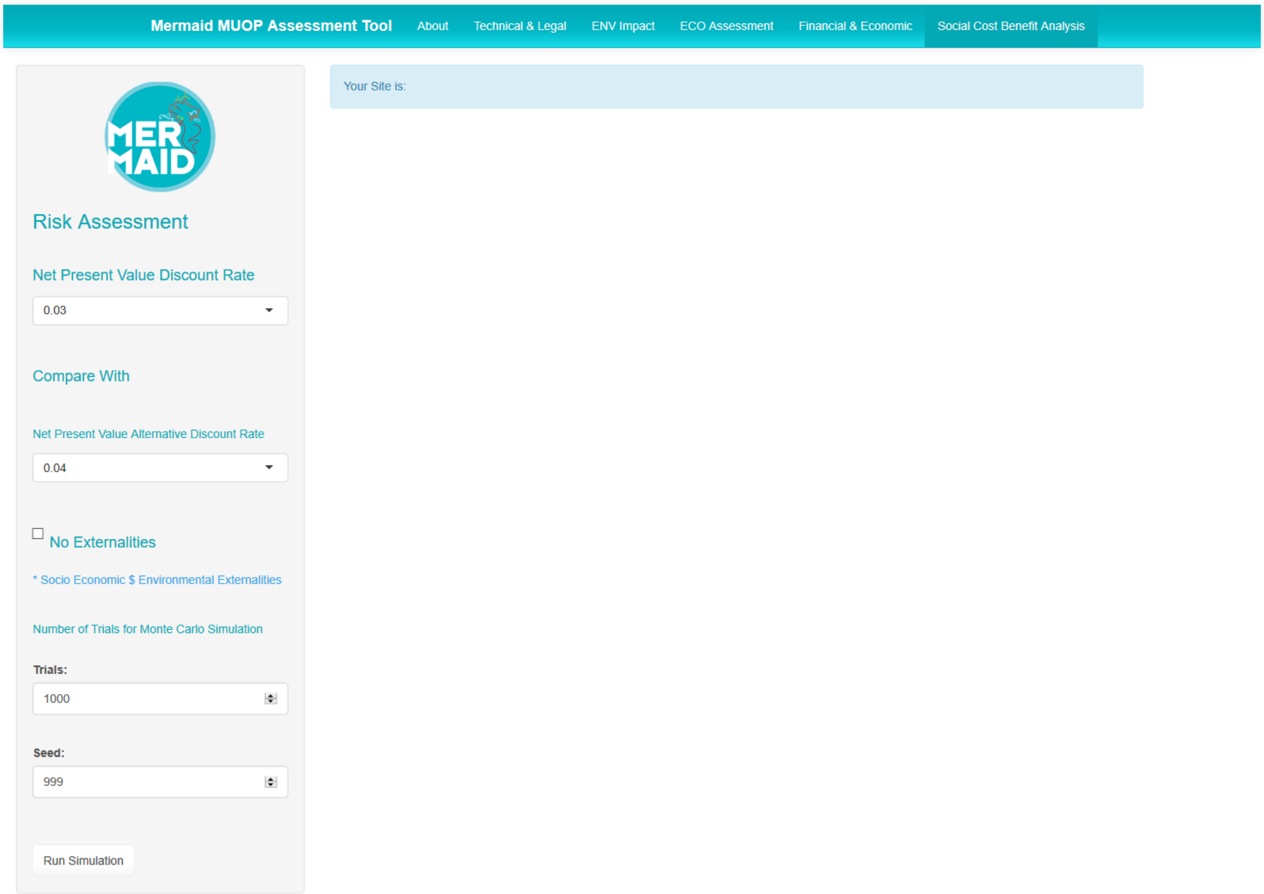
The user inserts specific requested data for the estimation of economic and financial benefits and costs.

Social Cost Benefit Analysis and Risk Analysis

It should be noted that the tool is able to compare at the same time the estimated net present value under different discount rates.

Furthermore, the tool calculates and compares the net present value for the case of including the monetized externalities and for the case where these are not included.

The detailed description of the tool and the user guide will be published in future publications.



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Due to lack of data, the social cost benefit analysis for the MUOP could not be applied. However, we provide the layout for this particular section of the tool