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AN INTEGRATED APPROACH FOR SUSTAINABLE ENVIRONMENTAL AND SOCIO-ECONOMIC DEVELOPMENT USING OFFSHORE INFRASTRUCTURE

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ABSTRACT

Seas and oceans offer a vast renewable energy resource and production possibilities with great potential for innovation and growth. Multi-purpose offshore platforms are ocean energy and aquaculture synergies developed in order to achieve efficient use of marine space. Regarding the construction and operation of such infrastructures, environmental and socio-economic benefits should be taken into account. This chapter uses the Ecosystem Services approach and the total economic framework for evaluating different designs of multi-purpose offshore platforms and a participatory approach to ensure their public acceptability.

INTRODUCTION

Our seas and oceans offer a vast renewable energy resource and production possibilities with great potential for innovation and growth, by creating new jobs, providing food and energy security, as well as facilitating marine research opportunities. Ocean energy and aquaculture synergies are currently being developed (including offshore wind farms, exploitation of wave energy, expansion of electricity

connections, and further development and implementation of marine aquaculture), helping to achieve efficient use of marine space.

Multi-use offshore platforms (MUOPs) correspond to the multiple uses of ocean space, including energy extraction, aquaculture and platform-related transport, as well as recreational activities. Hence, an offshore platform could facilitate wind and/or wave energy extraction infrastructure, aquaculture systems, maritime transport and recreational infrastructures.

The 2008 financial crisis has challenged the social and economic progress in the European Union (EU). Economic and environmental challenges, resulting mainly from globalization, climate change and demographic ageing, introduced to the scientific community and policy-makers the need to apply measures that would result in the sustainable development of the economies. These can be measures of mitigation that prevent economic and environmental challenges or adaptation measures that are actions to prevent or minimize the damage that is already caused. In this context, the European Commission (EC) proposed the "Europe 2020" strategy, a 10-year strategy to support employment, productivity and social cohesion in Europe. This strategy aims at smart, sustainable and inclusive growth. Those targets could be achieved through innovation, competitiveness, higher employment, social and territorial cohesion, resource efficiency and environmentally friendly actions. Following these directions, EU has developed a policy scheme to support and fund research projects with interdisciplinary and innovative character.

In line with Europe 2020, EU's Energy Strategy "Energy 2020" (COM/2010/0639) was designed to support the transition to reliable, sustainable and competitive energy systems, which need to overcome scarce resources challenges and growing energy needs by achieving energy affordability for consumers and businesses, as well as combat climate change and air pollution. Specific objectives and research areas of this strategy include the reduction of high-carbon energy consumption the low-cost, low-carbon electricity supply, the alternative energy technologies and sources by using new knowledge and innovative ideas decreasing the dependence on foreign fossil fuels, as well as the public engagement for a greener way of living. By 2020, the EU aims to reduce greenhouse gas emissions by 20%, increase the share of renewable energy to at least 20% of consumption and save at least 20% energy.

Regarding marine development and in order to take advantage of the opportunities that oceans provide, EU initiates Blue Growth, which is a long-term strategy that supports sustainable growth in the marine and maritime sectors as a whole and contributes to the goals of the "Europe 2020". On April 17th 2014 the European Parliament voted the Directive for Maritime Spatial Planning (2014/89/EU), which assists the Member States to develop plans to better coordinate the various marine activities, while ensuring their efficiency and sustainable development. The Directive sets minimum requirements for the establishment of national maritime spatial plans. These plans should identify all existing human activities, considering land-sea interactions, and identify the most effective way of managing them. Under this institutional framework, it is possible to develop innovative MUOPs that support the sustainable management of the marine space with regards to energy and aquaculture possibilities, as well as recreational activities.

Maritime Spatial Planning (MSP) requires the socio-economic assessment of the proposed plans, which should satisfy the conditions of sustainability (social, economic, environmental sustainability it time and space). Hence, MUOPs projects should be evaluated based on a framework that is in agreement with efficient maritime spacing requirements. Like any other investment, investments in innovative marine technological synergies involve costs today for benefits in the future. The identification of the Total Economic Value (TEV) of a project like this is important for the economic assessment stage that is required to be implemented.

In this chapter, a socio-economic assessment framework is presented that lies under the scope of sustainability and it is based on the ecosystem services approach. The ecosystem services approach identifies the different environmental services that benefit humans directly or indirectly and augments the precision of the economic valuation of these services. As it is already mentioned, for the case of MUOPs, is important to estimate economic produced benefits, in order to be able to move forward to the construction and the implementation of MUOP projects related to marine space management.

BACKGROUND

European Commission (EC) has supported and funded many projects related to the marine and coastal ecosystem. With regards to multi-use offshore platforms (MUOPs), EC has funded three projects that were developed under the EU's call for proposals, **"**The Ocean of Tomorrow", namely MERMAID, H2OCEAN and TROPOS Projects.

The MERMAID Project came as a result of EU's energy strategy "Energy 2020" and aims to develop concepts for the next generation of offshore platforms, which can be used, for multiple purposes. The project does not envisage building new platforms, but examining new concepts, such as combining structures for energy extraction, aquaculture and maritime transport, in order to discover the most technologically, environmentally and economically efficient platform designs. Additionally, MERMAID creates the appropriate links to two other projects, H2OCEAN and TROPOS. H2OCEAN focuses on the development of a wind-wave power open-sea platform equipped for hydrogen generation with support for multiple users of energy and aims at developing an economically and environmentally sustainable multi-use open-sea platform from which wind and wave power will be harvested. TROPOS aims at developing a floating modular multi-use platform system for use in deep waters, designed to be flexible enough in order to avoid being limited in geographic scope and to support recreational activities and tourist infrastructure.

Considering the EU initiatives and funded projects, the aspect of research and innovation plays a crucial role in achieving sustainable growth. It is essential for economic and social development as long as they reinforce an environmental friendly society that supports the future of the next generations. MUOPs are innovative technological synergies that are characterized by efficient production of positive economic benefits and spillover effects for the local as well as the regional communities.

These synergies support innovation and efficiency in energy exploitation and energy security. Furthermore, sustainable aquaculture aims to satisfy the growing demand for seafood, which is also related to food security. Aquaculture increases the global food production and decreases the impacts on wild stocks aquaculture. Aquaculture increases economic and production efficiency by centralizing operations, supporting smaller communities especially for marine coastal aquaculture. In addition, centralization of aquaculture promotes research opportunities and the application of innovative ideas on this particular economic sector (Tlusty, 2002). Additionally, greater job opportunities resulting in higher employability in the energy sector and aquaculture produce growth and boost the economy. Apart from these, other benefits could result from private facilities and recreational opportunities provided under the application of a MUOP. The MUOPs can attract private sector investments regarding facilities (e.g. private aquarium, hotel facilities) and recreational activities such as scuba diving, water sports and tourist visits.

Regarding the construction and application of a MUOP, a series of possible design options and technical synergies could be used, while satisfying the target for growth. The interaction between different elements of the design varies and depends upon the existence and flexibility of policies that consider social, economic and environmental management plans or constraints. In terms of engineering, each platform design should take into account the interactions between the structures and the characteristics of the chosen placement areas regarding the varying content of salt, the different morphological activity and the wave dynamics. This analysis seems to be challenging and complex in terms of the design and the cost required for the initial research stage. However, the physical design of the infrastructure is only one of the aspects that should be taken into account in such projects. In the context of sustainable development, the socio-economic and environmental aspects should be considered.

The development of the MUOPs under an interdisciplinary framework has to be optimized in order to reduce the cost of energy, allocate the ocean space efficiently for aquaculture, renewable energy and other types of facilities. Positive socio-economic and environmental benefits increase social acceptability and attract risk friendly capital to the industry supported by the MUOPs. However, negative environmental effects should not be neglected, since MUOPs are still constructions located into the sea and could possible affect the biological processes of the marine biodiversity and the ocean environment.

Hence, the environmental and socio-economic effects have to be examined and included in the analysis. All these require effective marine technology and governance solutions, based on sound socio-economic analysis, risk analysis and relevant stakeholders' engagement, to facilitate the installation, operation and maintenance of the offshore platforms.

This kind of interdisciplinary framework is in agreement with the implementation of the Marine Strategy Framework Directive (MSFD-Directive 2008/56/EC), adopted in June 2008, which aims to achieve good environmental status of the EU's marine waters by 2020 and to protect the resources regarding the marine related economic and social activities. The idea behind the MSFD is to promote sustainable use of the seas while protecting marine ecosystems.

According to World Commission on Environment and Development (1987), sustainable development is the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". More explicitly, sustainability can be achieved when the following conditions are simultaneously satisfied:

1. **Economic Sustainability:** Economic efficiency satisfies the condition that the marginal (social) cost of each production activity under consideration equals the respective marginal (social) benefit. This condition should be satisfied over time and space.
2. **Social Sustainability:** Social effects of the production activities under consideration should be acceptable and affordable by the different social groups identified in the region under investigation (social equity). This condition should be satisfied intra-generationally and inter-generationally.
3. **Environmental Sustainability:** The environmental and ecological effects of the activities under consideration are sustainable over space and time (ecosystem resilience).

The Ecosystem Services Approach Framework for Economic Valuation and Assessment

Multi-use offshore platforms (MUOPs) should be evaluated and economically assessed in a way that considers environmental, economic and social aspects. Hence, the socio-economic viability of the MUOPs' designs should be based on the previous mentioned three-dimensional sustainability condition.

Sustainable economic growth is associated with higher economic activity which can benefit not just the local communities but also produce benefits in regional level, especially by comparing ongoing coastal aquaculture with offshore aquaculture. Furthermore, considering the offshore nature of these installations, international cooperation is also possible with the MUOPs, which is something that has the potential to further increase the economic growth and spill-over effects.

From a welfare point of view, in order to assess the social desirability and economic feasibility of such infrastructures it is crucial to follow an interdisciplinary approach that will assist in integrating information from different fields of science into the analysis. Hence, biology, hydrology, chemistry and social science coordination is crucial in determining the impacts of each platform design on the environment. Typically, the evaluation of those impacts is established during an Environmental Impact Assessment (EIA), which aims to identify the possible environmental effects from a project. The information derived from the EIA can relate to the services that environmental resources provide to humans and assist decision makers to choose which and if a specific platform design is applicable from environmental perspective (Landsberg et al., 2013).

In addition to this, the ecosystem services approach provides a framework for integrating the whole ecosystem in decision-making, and for valuing the generated ecosystem services provided, ensuring that society can maintain a healthy and resilient natural environment for the current and future generations. It recognizes humankind and socio-economic systems as being integral parts of the ecosystem and moves spatially from smaller to larger scales, as well as from short-term to longer-term management practice (Lubchenco, 1994).

According to DEFRA's (Department of Environment, Food and Rural Affairs, UK) introductory guide defines ecosystem services as "services provided by the natural environment that benefit people. Some of these ecosystem services are well- known including food, fiber and fuel provision and the cultural services that provide benefits to people through recreation and cultural appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, purification of air and water, flood protection, soil formation and nutrient cycling, (p.10). Similarly, the Millennium Ecosystem Assessment (2005) has developed a widely use classification of the ecosystem services. These include:

- **Provisioning Services:** Ecosystem services that describe the goods provided by ecosystems. They include food, water and other resources such as energy.
- **Regulating Services:** Services that ecosystems provide by acting as regulators e.g. regulating the quality of air and soil by providing flood and disease control.
- **Cultural Services:** Non-material benefits that people obtain from the ecosystems, such as the enjoyment from recreational activities that require the use the ecosystem.
- **Habitat or Supporting Services:** Services required for the production of all the other ecosystem services.

According to this holistic approach, the functions of an ecosystem are not individually considered but in relation to other each other. The services can be the result of one or the interaction of more than one function. Therefore it is crucial to consider the ecosystem as a whole and take into account all relevant beneficiaries. The estimation of the Total Economic Value (TEV) of marine ecosystem services will be done after considering the benefits that these services provide to humans. Human welfare is a function of the benefits and the levels of benefits that the humans enjoy. Therefore, any change in the ecosystem

Table 1. Categories of ecosystem services

Provisioning Services	Regulating Services	Cultural Services	Habitat or Supporting Services
• Food • Raw materials • Fresh water • Medical resources	• Local climate and air quality • Carbon sequestration and storage • Moderation of extreme events • Waste-water treatment • Erosion prevention and maintenance of soil fertility • Pollination • Biological control	• Recreation, mental and physical health • Tourism • Aesthetic appreciation and inspiration for culture, art and design • Spiritual experience and sense of place	• Habitats for species • Maintenance of genetic diversity

De Groot, Wilson, & Boumans, 2002.

services, will result in changes in the provided benefits, which will influence the value that the human place on the environment. Relating ecosystem services to human welfare, enables us to better understand the actions that affect the status of the environment which result in changes in the welfare. Therefore, economists can value any change in the welfare in terms of changes in the biological, physical and/or chemical status of an ecosystem. In the following table, ecosystem services potentially affected by the construction and operation of MUOPs are presented.

MUOPs have the potential to be both beneficial but also detrimental to the environment. For example, marine installations could produce artificial reefs effect and attract different fish species, enhancing biodiversity and fisheries (Inger et al, 2009). According to Langhamer and Wilhelmsson (2009) wave power foundations, as well as added structural components, could both enhance abundances of associated fish and invertebrates based on artificial reefs effect, and have adverse effects on a number of certain local species. There are indeed concerns over the potential negative impacts on biodiversity from the marine renewable energy installations, including habitat loss, collision risks, noise and electromagnetic fields. Benthic habitats and other marine organisms could be disturbed by the installations, noise pollution and sediments produced during the construction and operation phase. In addition, a MUOP design that supports excessive use of marine resources will still constitute a threat for the marine biodiversity.

Table 2. Marine goods and services that could be affected by the implementation of the offshore multi-use platforms

Renewable Goods	Non-Renewable Goods	Renewable Services
• Marine animals for food • Marine animals for recreation, e.g., whale watching • Seaweed • Medicines • Other raw materials, e.g., building materials, ornaments • Energy, e.g. wind, wave, tidal, thermal • Water	• Oil and gas • Sand and gravel • Marine minerals	• Habitat, e.g. nursery areas for fish • Protected areas • Flood and storm protection • Nutrient cycling • Biological regulation • Waste processing • Marine transportation routes • Atmospheric and climate regulation • Carbon sequestration • Tourism, leisure and recreation • Cultural heritage and identity • Education and research • Aesthetics

Intergovernmental Oceanographic Commission Manual and Guides No. 53, ICAM Dossier No. 6.

Furthermore, impacts from aquaculture activities could include changes in organic matter content, alteration of inorganic and organic chemistry of farm water and sediments, as well as modification of biomass and biodiversity. In addition, pollution impact from maritime transportation and operation of recreational facilities is also possible.

Finally, visual impacts, restrictions of areas and high traffic on the marine pathways can affect human welfare. Hence, appropriate environmental management and technical design of MUOPs could increase biodiversity and result in benefits for the marine ecosystems.

The implementation of MUOPs should be line with effective maritime spatial planning and marine initiatives that aim to alleviate negative effects produced by marine human activities. A European Commission's report on economic effects of maritime spatial planning (2011) recognizes the direct benefits from maritime spatial planning to be the efficient coordination and effectiveness for governments, the lower costs for companies and the enhanced investment possibilities. In addition, indirect effects derive from combining activities and uses. In particular, there would be less human impact on the ecosystems, in relation to sustainable fishing, less CO_2 emissions by using renewable energy synergies and higher biodiversity in case of environmentally cautious technologies.

In order to assess and choose the most appropriate MUOP design, it is required to estimate the production and demand function of each of the possible platform designs. The production function consists of the private/financial, social and environmental costs. The demand consists of private, financial, social and environmental benefits. Private/financial costs and benefits are based on actual financial data. On the contrary, the social and environmental benefits might be viewed as positive or negative externalities and thus the market cannot capture their value. This makes their estimation in monetary terms difficult. Moreover, the benefits may be derived from the actual use (i.e. direct and indirect) of the ecosystem, whereas other types of benefits can be derived only from the passive use of the ecosystem. In order to estimate the TEV of the benefits dwelling from an ecosystem it is crucial for an economist, to identify the ecosystem services generated by the functioning of the ecosystems, identify the types of benefits these ecosystem services provide to individuals, then to associate the different types of values related to these benefits and lastly to choose a method that is able to account for these characteristics to elicit the value of the ecosystem. After identifying the ecosystem services and estimating their values, we examine how each proposed design affects these services. We can then compare the designs and decide based on all the values generated which design is the most preferable.

The most commonly used classification of values is in *use* and *non-use* values. More specifically, under use values we consider:

- *Direct use values*, as those generated from the direct use of natural resources, such as the provision of consumable goods, fish and energy;
- *Indirect use values*, as the generated present and future benefits that are not consumed in the typical sense during use. To clarify that, this may refer to public goods such as carbon sequestration, increased productivity etc.

The passive or non-use values can be grouped as follows:

- *Option value* that dwells from the potential future use of a resource;
- *Bequest value*, which is the amount of money that people would be willing to pay to preserve a natural resource in order to pass this on to future generations;

- *Existence value*, which is the amount of money individuals would be willing to pay in order to maintain ecosystem service as it stands;
- *Altruistic value*. This type of value relates to the satisfaction obtained by the individuals by knowing that other users can also enjoy an environmental good.

Table 3 describes the classification of the types of values and examples related to marine and coastal environment. In the next section we are presenting the main valuation methods used to estimate these values.

Approaches of Economic Valuation

As mentioned before natural resources, generate services that benefit human, however it should be mentioned that each individual attach value to natural resources, based on the generated benefits he/she enjoys. Therefore, from a policy point of view, it is important to find ways to identify the connection between the environment and the individual and social welfare. This is the only way to design policies that can lead to the optimal allocation of resources across time and space. To do that, it is necessary to identify individual's preferences for environmental goods.

The difficulty of valuing an ecosystem lies in the fact that, such goods provide a wide range of services that have the characteristics of a public good. This means that the use of a resource one person does not affect the use of the same resource by another person. Additionally, no individual can be excluded from using the resource. Since the provision of a good or service incurs costs, individuals have the incentive to conceal their preferences in relation to the quantity they desire to avoid being charged for it. This fact makes the market unable to put a price on environmental resources with public good characteristics. A consequence of that is that policy making cannot yield optimal results, unless preferences are known.

To tackle the aforementioned issue, economists have developed a wide range of methods to reveal individuals' preferences and assign a value to environmental goods. These methods are discussed in detail in the literature (see, for example, Barbier (2007), Bateman (2007), Bateman et al. (2002a), Champ et al. (2003), Freeman (2003), Hanley and Barbier (2009), Heal et al. (2005), Kanninen (2006) and Pagiola et al. (2004).

Table 3. Category of the total economic value (TEV) of coastal and marine ecosystems

Type of Values			**Examples**
Use Value	Direct Use Values	Market Outputs	Fisheries, Tourism
		Un-priced benefits	Recreation, Local culture
	Indirect Use Values	Un-priced benefits	CO_2 sequestration, Watershed protection
Non-use Value	Option and Quasi-option Values	Market outputs, Un-priced benefits	Potential unknown biodiversity, Future recreation options
	Existence Values	Un-priced benefits	Satisfaction from the knowledge of existence and conservation of seas and species
	Bequest Values	Un-priced benefits	Satisfaction from passing the availability of marine related benefits to future generations

Pearce and Moran (1994).

Overall, two families of techniques can be identified, namely the Revealed Preference (RP) and the Stated Preference (SP) methods. In addition to these, the Benefit Transfer (BT) technique uses the values estimated in primary revealed or stated preference studies, for similar sites. Using this information and by making adjustments to account for socioeconomic and environmental differences between cases, values are adjusted so that they are in line with the preferences of individuals in the site of interest. These adjustments account for differences in the socioeconomic and environmental parameters between the sites. BT is a popular alternative for the valuation of ecosystem goods and services, since it is less costly and less time-consuming. Bergland *et al.* (1995) discussed three main approaches to BT:

1. The transfer of the mean household WTP (Willingness to Pay),
2. The transfer of an adjusted mean household WTP and,
3. The transfer of the demand function.

The first approach assumes similarity in good and socio-economic characteristics between the study and target site, while 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. The suitability of this method depends on the strong relation between the original site and the study site. Both sites should have similar characteristics with respect to location, socio-economic factors and environmental change. In addition, the original valuation study should have been carefully conducted and the valuation method used should have been reliable.

De Groot et al (2012), presents monetary values of the marine ecosystem services, which can be affected by technological synergies such as MUOPs. These values could be transferred to study sites where a MUOP project is planned and by taking into account the effects on ecosystem services we would derive the monetary value of the effect produced by the implementation of the MUOP.

This is a summary of results from numerous studies. Hence, a next step for the economic valuation would be the application of a meta-analysis. Meta-analysis includes methods and techniques that are able to estimate values of ecosystem services by relying on reviews and summaries of results of empirical studies. Furthermore, an alternative to the benefit function is the meta-regression (Stapler & Johnston, 2009). Meta-regression examines the heterogeneity across studies and the effects of explanatory variables (such as income, sex, education) on the estimated values. For example, Ahtiainen (2009) used meta-analysis to derive the economic value of marine water quality improvements.

Nevertheless, as far as Revealed and Stated Preference techniques are concerned some of them are presented to foster understanding.

Revealed Preference Methods (RP)

In order for the researcher to value a change in the circumstances using these types of techniques, actual data should be obtained. The source of this information would be the market, in which the goods/bads resulted from a change would be traded. Therefore, the researcher needs to observe the actual behavior of the consumers in a real market setting. This will results in obtaining the market "footprint" of the good (Russell, 2001). Following, some of the RP methods that have been widely used in the literature are presented.

Table 4. Summary of monetary values for each service per biome (values in Int.$/ha/year, 2007 price levels)

	Marine
Provisioning Services	**102**
1 Food	93
2 Water	
3 Raw materials	8
4 Genetic resources	
5 Medicinal resources	
6 Ornamental resources	
Regulating Services	**65**
7 Air quality regulation	
8 Climate regulation	65
9 Disturbance moderation	
10 Regulation of water flows	
11 Waste treatment	
12Erosion prevention	
13 Nutrient cycling	
14 Pollination	
15 Biological control	
Habitat Services	**5**
16 Nursery service	
17 Genetic diversity	5
Cultural Services	**319**
18 Esthetic information	
19 Recreation	319
20 Inspiration	
21 Spiritual experience	
22 Cognitive development	
Total Economic Value	**491**

(De Groot et al, 2012)

Hedonic Pricing Method (HPM)

The underlying principle of HPM is that the price of a certain good encompasses the value of its individual characteristics (Lancaster, 1966). For instance, the price of a car might depend on the power of the engine, the size and its fuel consumption. Therefore, HPM endeavors to estimate the value of a certain good by isolating the different components of the value, expressed in the price. HPM application is undertaken using regression analysis to estimate the hedonic price function, which relates the price of the certain good to its characteristics. Regression analysis is a statistical process that tells how much the dependent variable (price of the good) will change when other independent variables (characteristics) change.

In order to implement a HPM study the researcher uses the market where a bundle of the good under investigation is traded. More specifically, in an attempt to extract the value of a non-market service, the researcher makes use of a market good through which the non-market service is traded. Therefore, for HPM the interest lies in surrogate markets. HPM is most commonly used in property markets to estimate the value of local environmental goods. More explicitly, the results from the regression analysis indicate how much property values will change for a small change in each characteristic of interest, keeping all other characteristics constant. For example, following the aforementioned arguments, an apartment can be analyzed in terms of the number of rooms, the number of windows, proximity to schools etc. The market price of the apartment can be thought as a function of these characteristics (hedonic price function). Consequently, if one wants to estimate how much a consumer is willing to pay (WTP) for living in a neighborhood with low crime rate, the comparison of two neighborhoods with similar socioeconomic characteristics, but different crime rates would result in a price premium for the apartment in the area with lower crime rate. This would be the trace of the market value of the good for the consumer. This implies the estimation of the demand function (marginal WTP), which can be generally identified by including observations on households with the same characteristics facing different implicit prices.

For the case of maritime spatial planning, changes in land prices with regards to coastal residential areas or business development at coastal areas that are facing pressures by maritime activities could reflect the monetary value of negative environmental effects such as water pollution. By going offshore will potentially mitigate for the negative effects produced by human activities. Hence, the estimated monetary value should be considered as positive benefit when a cost benefit analysis (CBA) for the implementation of a MUOP design is undertaken.

The issues arising from this method are that it cannot estimate non-use values and in addition, outside influences will probably affect the estimated prices resulting in value overestimation or underestimation for the environmental good of interest.

Travel Cost Method (TCM)

TCM is associated with estimating the value of the use of non-market goods for recreational purposes.

Methodologically, this method focuses on the number and frequency of trips to a certain location for recreation made by the individuals and the cost to realize these trips. This cost encompasses not only the expenses such fuel, fares and so on, but also the cost in terms of time spent travelling. The opportunity cost of time allotting to travelling rather than to other activities is estimated by taking into account the individual's wage rate. It is assumed that individuals choose to work up to the point at which an extra measure of time spent at work is worth the same to them as the same extra measure of time spent at leisure (recreational trips).

Variations of the travel cost method include the zonal travel cost approach, which includes secondary simple data collected from visitors, the individual travel cost approach, which uses detailed surveys provided to visitors and the random utility approach, which includes more detailed statistical techniques, incorporating survey and other data. In the case of individual travel cost approach, the information needed by the researcher is obtained by directly asking individuals on the site. More explicitly, including information about the quality of the recreational site allows for estimation of change in value of the location if there is some quality change. Using this information and econometric techniques similarly to HPM, the researcher can for example estimate the effect of degradation of water quality on the demand for recreation. It is rational to assume that such an effect would lead to the demand function moving to the left, thus lowering consumer surplus, which would mean that the individuals would be willing to undertake lower cost or travel less frequently to the specific site, due to the environmental degradation. It should be noted that the first two approaches can measure the environmental qualities as they are the same for all individuals and households. However, the random utility approach is used when we want to estimate benefits with regards to specific recreational site characteristics, or quality changes, rather than for the site as a whole. This is possible since, the random utility approach takes into account substitute sites as well.

In the case of MUOPs, changes in coastal visiting behavior due to negative visual effects caused by marine offshore infrastructures could provide information with regards to welfare changes. Hence, we can monetary value the visual effect. This is done by estimating the demand for visits at the beach of a specific location in which an offshore wind farm is located and compare them the relevant demand of visits in case where there is no wind farm.

One important issue of this method is that, we cannot easily distinguish among the different purposes that the trip could be undertaken. Furthermore, people valued certain recreational sites may choose to live nearby. This means that their real cost is not reflected adequately in the estimated price and demand using this method.

Averting Behavior and Preventing Expenditure

Those methods are based on the notion that when individuals face utility loss due to negative externalities, they are willing to pay for goods or services in order to mitigate the negative effects on their utility. For example, in towns, where tap water is not potable due to its low quality, individuals may be willing to purchase bottled water or install filters to avoid the negative effects on their health. The changes in the household expenditure on these substitutes due to the public bad water quality can be used to provide a measure of the value that the households assign to higher water quality.

Mitigation strategies applied in coastal areas for the purpose of keeping the coastal water clean and secure the level of local biodiversity could be considered in order to estimate the environmental positive benefit of moving offshore instead of onshore.

Stated Preference Methods

In contrast to Revealed Preference techniques that use already existing markets, Stated Preference methods are survey-based techniques, which use hypothetical markets.

Their foundation lies in the Random Utility Theory (RUT). According to RUT, the researcher is able to observe only the *representative utility* of the individuals, based on their observed choices. On the contrary, the individuals' utility is only known by the individuals. In this context individuals' utility is described as:

$$U_{jn} = V_{jn} + e_{jn}, j = 1,\ldots,J, n = 1,\ldots,N$$

where U_{jn} is individual's n utility, V_{jn} is what the researcher observes based on individual's n choices and e_{jn} is the error term.

The flexibility of this framework and the increased computational ability of the computers are the reasons why these methods have been used extensively during the last decades.

Another reason is their ability to estimate use and non-use values, which RP fail to achieve. Additionally, these methods are of relevance when a researcher is interested in valuating a change in a policy/ good *ex ante*. To clarify this, RP methods require the existence of the demand curve for a good. In cases, where markets do not exist the demand curve is concealed, due to individuals hiding their preferences. This hurdle can be overcome with the use of hypothetical markets, which are used by the SP techniques. It goes without saying, that SP can be used for real goods when markets already exist, but also for hypothetical goods when markets are missing. A detailed description (functioning, institutional setting, provision of the good) of the constructed market is provided in the survey. Therefore, under a scenario respondents are asked to state how much they would be willing to pay for the provision of a good. As it is obvious, this kind of analysis is operational under the assumption that the respondents behave in the same way no matter if the market is real or not.

Since the estimated values are derived from people's responses to hypothetical questions under hypothetical markets, these methods have become quite controversial. There are conceptual, empirical and practical problems associated with these methods that are debated in the economics literature due to non-observability of actual individual behavior.

Contingent Valuation Method (CVM)

CVM is probably the most widely used SP method (examples can be found in Venkatachalam, 2004). CVM has been strongly criticized due to the use of hypothetical markets, which imposes biases in the data (Diamond & Hausman, 1994), such as hypothetical bias, information bias, strategic bias and sampling selection problem. Nevertheless, its ability to elicit both use and non-use values, consists its significant strength.

The implementation of a CV survey questionnaire has many common elements with the Choice Experiment methods, which is described in more detail in the next section. For example, the questionnaire consists mainly of three parts. The first part includes questions about the stances of the respondents towards the good under investigation. The second part follows with the presentation of a script that provides respondents information about the good, the structure and the functioning of the market, the provision of the good and the method of payment. This is the stage where the respondents are asked to express the value they assign to the good based on their preferences and the characteristics of the hypothetical market. Finally, the last stage involves questions about the demographic and socio-economic characteristics of the respondents. After the information is obtained, the next step is to employ statistical methods to analyze the data.

According to Bateman et al., (2002), one of the most significant problems of CVM is that although it provides a realistic description of the structure of the market and the good, respondents' experience with this market cannot be compared to real life experiences that the respondent might have with a good.

An application of this method to the MUOP case could be a study for eliciting individual's preferences towards renewable energy generation and their WTP for the construction of a multi-use platform that incorporates wind and wave energy extraction. An applicable survey design would have included questions related to environmental consciousness measures (knowledge about various energy sources conventional and renewable, actions undertaken to reduce energy consumption, attitudes towards the construction and implementation of the renewable energy infrastructure in the ocean). In addition, the survey would have the contingent valuation scenario proposed to the respondents, such as the specific platform design that is envisioned to be implemented offshore. Finally, socioeconomic data and demographics taken from the individual responses to the questionnaire will be used for deeper and more informative statistic analysis.

This method could be used to estimate environmental costs of implementing the MUOP by deriving the WTP for reduction of negative effects on marine biodiversity due to MUOP's operation. Ressurreição et al (2011) used a contingent valuation method to estimate the public's WTP to avoid loss in the number of marine species. The study considered mammals, birds, fish, invertebrates and algae as proxies of marine biodiversity and the aim of analysis was to estimate from a multi-site perspective public's WTP to avoid increased levels of species loss (reduction of species richness) for different marine taxa.

Choice Modeling (CM)

Similar to CVM, CM is also a technique that makes use of questionnaires.CM has its roots to Lancaster's theory (1966), according to which a good can be described as a bundle of characteristics. Comparisons between goods can therefore be made in terms of the characteristics and the levels (higher-lower, more-less, etc.) they take.

In a CM survey, the respondents are thus asked to choose among various alternatives instead of various goods. More precisely, respondents might be asked to rank or rate the alternatives, or choose the alternative they prefer the most. According to the task the respondents have to undertake, a CM study can be characterized as:

- Contingent ranking, where the respondent ranks several alternatives;
- Contingent rating, where the respondent rates different scenarios on a 1-10 scale;
- Paired comparisons, where the respondents choose their preferred alternatives out of a set of two choices and then they are asked to manifest, using a scale, how strong their preferences are for this alternative.

An additional method that belongs to the family is *Choice Experiments* (CE), where the respondents are asked to choose their most preferred out of a set of various alternatives that consist of different levels of each attribute described the good under examination. These choice sets are created based on the experimental design theory. Usually, but not always, one of the alternatives described is the status quo, which consists the opt-out option for the individual. Such an alternative is needed in order to produce welfare-consistent estimates.

As it is already mentioned, MUOPs can be benevolent to the marine environment. For example, MUOPs due to nutrient flows produced by aquaculture could facilitate the accumulation of algal blooms. Taylor and Longo (2010) applied a choice experiment to assess the recreational damage associated with algal blooms caused by nutrient flows into Varna Bay, Bulgaria. The estimated WTP for a program that provides beaches free from algal blooms represents the negative economic value of harming the ecosystem. Another example is the application of a choice experiment to estimate the monetary value of social costs and benefits associated with renewable energy programs. More explicitly, Emmanouilides and Sgouromalli (2013) estimated the economic benefits from the environmental impacts on landscape, wildlife, noise levels and quality of air due to renewable energy use.

Although both CE and CV are based on discrete choice analysis methods which elicit WTP from the tradeoffs made by the respondents when they are choosing their most preferred options, CE is usually more complicated than CV method. After the implementation of the survey, we can estimate the average value for each attribute and connect it to the relevant population in order to calculate the total benefits derived from this particular good.

CV and CM share many features and to a great extent can be used for the same purposes, however as Bateman et al. (2002) point out, the choice between one over the other should follow the consideration of several issues.

First, when the researcher is interested in estimating the total value of a change rather than the value of attributes of a good, service, or policy CV is more preferred. On the other hand, CM is more effective in providing information on individuals' preferences about specific attributes. Furthermore, respondents can more easily respond to a CV questionnaire. This might be of relevance, when the cognitive effort to respond to a questionnaire is higher due to the complexity of the good. Finally, CM analysis deals with most of the biases generated in the CV method (strategic bias, protest bids, embedding effects, and yea-saying bias).

A final note on economic valuation of natural resources is that the appropriateness of each technique is based on several questions that should be clearly answered prior to the valuation exercise. More specifically, it is important the researcher to be aware of the type of benefits accruing from the resource under examination. Benefits that have the characteristics of a private good could be valued by observing the prices in the market, whereas benefits of public nature could only be valued with the use of non-market valuation techniques as these described above. Moreover, it is important to identify the stakeholders affected by any changes in the status of the natural resource. To some extent this is another restriction that has to be fulfilled in order for the most appropriate technique to be chosen. For example, changes in the chemical status of the water would probably result in income losses for fishermen and aversion of tourists into visiting a specific location. However, for the first group of individuals the value of the sea is related to marketed benefits, whereas for the latter group that their indulgence results from recreational activities, the benefits cannot be priced in the markets. Therefore, it is usually expected that the willingness to pay of different groups will vary. For example, Lindberg et al., (1999) find that the attitudes towards tourism development on the island of Børnhom (Denmark) are different across local communities, with some valuing the generation of income more than the generation of traffic.

Stakeholders Approach and Qualitative Research Methods

In the presented methodology the ecosystem services approach is put in the core of the valuation of environmental goods and in our case the valuation of the different proposed multi-purpose platforms' designs (MUOPs). Nevertheless, there are barriers embedding the ecosystem services approach.

According to UNKEAFO (2014), these barriers are expressed in micro and macro level. At the micro level there might be limited money or human resources and lack of data available to officials who undertake the appraisal. Also, there might be limited awareness of the ecosystem services concept and difficulty in understanding the concepts underlying this approach. At the macro scale, which involves wider social and political context, social values and hence political priorities might not support the ecosystem protection. Social and political collaboration and support in raising awareness improve the understanding between ecosystem and humans, as well as engages better decision-making.

Apart from taking into account technical, socio-economic, ecological aspects, it is crucial to involve stakeholders in order to generate a solution to this problem. A stakeholder refers to any organization, group or individual affected by, with an interest in, or influence over, a decision making issue. For our case, views if scientific experts, policy experts, representatives from public, private or third sector organizations as well as members of the wider public should be taken into account and introduced to a participation process. Relevant stakeholders should be engaged in decision making, exchanging information and interacting, sharing their ideas to the decision-makers and project coordinators.

For a multi-use platform project, conflicts can be created between different interest groups from different economic sectors (e.g. industry, household, and tourism) and non-economic sectors (e.g. environmental groups). We could have increasing social opposition near shore mainly due to other competitive uses. For example, fishermen's livelihoods could be significantly affected by the installation of offshore wind turbines, reducing their fishing activity and production. In addition, their high environmental impacts near shore may also create social opposition, while their moving offshore reduces the "not in my back yard" opposition from residents.

We can minimize such conflicts by considering the views of these key stakeholders into the design and application of the platforms. It is important to be able to provide evidence of the benefits from these installations and also have institutional support. Additionally, by taking into account stakeholders' opinions regarding the ecosystem services provided, the results from the market and non-market valuation can be validated.

In order to elicit the value, the stakeholders assign to the good we may be able to produce more sound results by using qualitative research methods. We briefly present these methods below:

- **Focus Groups and In-Depth Interviews:** A moderator brings together a group typically consisted of 7-10 people unfamiliar with each other. The participants share common interests or characteristics and are encouraged to interact under a specific environment provided by the moderator. The aim of this interaction is to identify trends and patterns in participants' perceptions towards the research topic under consideration (Kairuz et al. 2007). This method does not pressure the participants to vote, plan or reach consensus (Krueger, 1988). In-depth group interviews are similar to focus groups in some aspects but they aim to elicit a well-established picture of the research topic under consideration. In-depth groups usually consist of people considered the experts on this particular topic. (Milena et al. 2008).
- **Citizens' Juries:** A sample of citizens has the opportunity make judgments as they would in legal juries. It brings together a group of 12-20 randomly chosen citizens into a panel that resembles a profile of the community under specific criteria. The panel aims to agree on the best way to deal with an issue of public importance considering evidence from experts and other stakeholders. Usually, the citizens' jury takes place over a number of days and it concludes with the panel preparing a report that includes its recommendations and the dissenting opinions. (Carson et al. 2003)
- **Health-Based Valuation Approaches:** The approaches measure outcomes related to health by taking into account their impact on the length and quality of life. They have the potential to identify changes in society's values as the quantity and/or quality of the ecosystem services changes. According to the Joint Nature Conservation Committee, the techniques used are based on the idea that society values healthier years than unhealthy ones. The "Quality-adjusted life years" technique takes into account the degree of human health improvement or deterioration over time

conditional to the life expectancy. The “Disability-adjusted life years” technique estimates the loss of healthy life from premature death, disability or abnormality. Finally, the “Healthy-years equivalent” technique assesses life’s health profile under different health states.

- **Q-Methodology:** Q-methodology provides a foundation for the systematic study of subjectivity, a person’s viewpoint, opinion, beliefs and attitude (Brown, 1993). It is commonly used in our case to investigate how individuals understand, think and feel about environmental problems and their possible solutions. It identifies typical ways of people thinking about environmental issues, the reasons of accepting or rejecting policy implementations. (Barry & Proops, 1999). People are presented with a sample of statements about the topic (Q-set) and they are asked to rank-order the statements from their personal point of view, according to their preferences. This is how they give their subjective meaning to the statements, revealing their viewpoint and personal profile (Exel & de Graaf, 2005).
- **Delphi Surveys and Systematic Reviews:** Delphi surveys and systematic reviews are means of summarizing knowledge based on expert opinion (Delphi) or scientific evidence relating to particular topic under consideration (systematic reviews). Delphi method focuses on forecasting technological and social developments by prioritizing and identifying policy targets and expert opinions regarding a specific issue. It is a structured group interaction and dialectical process, based on opinion collection and feedback using a series of surveys and questionnaires. The results of each survey are presented to the group and then a questionnaire built upon these results is used in another round of opinion collection (Steyaert & Lisoir, 2005). On the other hand, a systematic review is a literature review focused on a specific research question that tries to identify, assess, select and synthesize all high quality research evidence related to this question.

These methods can be used in parallel with the monetary techniques provided by the total economic framework under this disciplinary approach. More explicitly, in the case of hypothetical based–survey methods, the design and implementation of valuation questionnaires requires to be carefully established based on relevant stakeholders’ views. In addition, these surveys require phases of pretesting until the final survey is ready to be applied to the relevant groups. Furthermore, the relevant stakeholders to answer the questionnaires could be identified based on the stakeholder approach and different techniques involved.

For example, during focus groups, the researchers would ask general questions, including questions about peoples’ understanding of the issues related to the MUOPs and the environmental good or service being valued, whether they are familiar with the MUOP concept and what are the important attributes involved in the implementation of a MUOP for the respondents. Accordingly, researchers would involve relevant scientists and experts with regards to identifying different levels of the attributes involved in the valuation study (in case of applying CE method). It is crucial to take into account stakeholder’s familiarity with the MUOPs, as well as consider factors of quality, quantity, accessibility, substitutions and reversibility of any effect produced by the MUOPs. Pre-testing of the questionnaires plays an important role to the statistical analysis. It includes different ways of asking questions and alterations in the description of the good, in order to identify whether the questions and information are sensitive to changes.

In later focus groups, the questions would get more detailed and specific, to help develop specific questions for the survey, as well as decide what kind of background information is needed and how to present it.

CONCLUSION

The implementation of offshore infrastructure that facilitates different functions under the scope of achieving sustainable environmental and socio-economic development seems to be too complex to be dealt with the knowledge and tools of a single discipline. Hence, an interdisciplinary approach is required. According to European Union Research Advisory Board (April, 2004), “many major breakthroughs in science take place at the boundaries or intersections of disciplines. While mono-disciplinary studies will continue to play an important role the solution to many of today’s complex problems must be addressed using a multidisciplinary approach”.

The approach discussed in this chapter implies the cooperation of researchers, in order to apply a methodology that integrates socio-economic, financial, environmental, technical and legal research aspects to provide the policy makers with a solid solution to the problem of marine and energy resources scarcity, optimizing the use of marine space. This particular analysis is needed considering the different information requirements for the multi-dimensional nature of the marine infrastructures and their potential.

In our framework of analysis we concentrated on the implementation of the ecosystem services approach, the different valuation methods of the total economic value of services and the participatory approach. Ecosystem services approach as it is already mentioned connects the ecosystem and its functions with human welfare. In this way, we can apply an interdisciplinary analysis including environmental and socio-economic aspects that most of the project assessments in the past did not include or it was difficult to consider duo to the characteristics of the good under examination. Hence, by considering the changes in the ecosystem services provided by the marine environment and the monetary values added to these changes, we have an estimation of generated benefits derived from the application of a multi-use platform. Consequently, we can further initiate a cost benefit analysis to inform policy makers about the profitability of a proposed project, while at the same time we are applying a participatory approach that provides insight regarding relevant people’s preferences and views on the subject of the project.

In conclusion, this methodology improves the cooperation between the different scientific disciplines and assists in policy making by making complete analysis on project recommendations considering social, economic and environmental parameters for sustainable development and social acceptance.

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