Methodology for the evaluation of socio economic impacts of coastal projects
Case Study: Artificial Surf Reef in S. Pedro do Estoril, Cascais, Portugal

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ABSTRACT
This paper describes a methodology for the evaluation of socio economic impacts of coastal projects considering three main decision factors: Changes on the Recreational Beach Use, Biodiversity Loss and Tourism Improvement. The methodology was applied to the case study - Artificial Surf Reef in S. Pedro do Estoril – which is a specific type of coastal structure. This structure aims to improve the surf conditions in the São Pedro do Estoril Beach, and, consequently, contribute to the economic development of Estoril.

An Environmental Impact Assessment evaluated the project's impacts at the local, national and international level, including environmental and social impacts. Due the importance of the socio economical aspects concerning the project success, a special focus was put on this evaluation which comprised a pre-public consulting stage to hear from the opinions of those who are interested or possibly influenced by the artificial surf reef.

KEY WORDS: Methodology, Artificial Surf Reef, Environmental impact, Socio Economic

INTRODUCTION
There are different types of coastal structures, such as harbours, marinas, pontoons, reefs (for fisheries promoting, surf improvement and coastal protection) and also wave energy units that are now being placed not far away from the coast. Normally, the Environmental Impact Assessments (EIA’s) referring coastal projects consider, as main decision factors, coastal morphology and hydrodynamics, water quality, biodiversity and socio economics. However, in what concerns socio economics, the impacts are related with the project benefits comprising issues such as the raising of the economical income due to the increase of the maritime traffic or due to the creation of new commercial and tourist infrastructures (for example, for harbours and marinas). The negative effect due to the construction of a new coastal structure in the practice of nautical sports, such as surf, is rarely considered.

Hence, it is important to include this issue when analysing socio economics, not only to assess if a certain use is affected, but also to evaluate how much it will affect the economics and the population at the local level.

The importance of the definition of a methodology for the evaluation of socio economic impacts of coastal projects became evident with the development of the Environmental Impact Assessment (EIA) for the project of an Artificial Surf Reef in São Pedro do Estoril (Custódio et al. (2008). Due to the importance of surfing in the Council of Cascais, the implantation of an artificial surf reef in the neighbourhood of the beach of São Pedro do Estoril was proposed by the Municipality of Cascais. For this purpose, the Câmara Municipal de Cascais (CMC), the Instituto Superior Técnico (IST), the Laboratório Nacional de Engenharia Civil (LNEC) an the Faculdade de Ciências da Universidade de Lisboa (FCUL) agreed in a protocol to produce the necessary studies for the development of strategic projects in the coast of Cascais, including the Environmental Impact Assessment of the project. When searching for a specific methodology to quantify the benefits from improving surf conditions and also to account for important issues such as coastal protection and beach use, it became evident that such integrated approach was not a common practise.
The proposed methodology for the assessment of socio economical aspects related with coastal projects, is based on three decision factors: Changes on the Recreational Beach Use, Biodiversity Loss and Tourism Improvement. These three components are to be integrated in a global impact assessment of coastal projects, either to assess the possible impact on surf practise or tide regime either to quantify the benefits for improving surf practise.

A description of the main social economical factors is provided bellow:

Changes on the Recreational Beach Use – this component evaluates the recreational beach use based on the perception of its users and the project influence on coast line protection, sediment recharge and sea conditions (these can be assessed and controlled through the correct design and location of the new structure)

Biodiversity Loss – this component identifies the local biology (fauna and flora species), the life cycles and the marine conditions, and includes also the evaluation of the species development caused by the construction of the new structure.

Tourism Improvement – this factor considers the importance of the practice of sea sports, such as surf, and the importance of the tourism related with this type of activities. It is very important to evaluate the existent infrastructures, the actual development of the sea sports, as well as the perception and receptivity of various local entities about the necessity and the utility of the new project. It is also important to evaluate the type of activities that can be improved by the new project and its influence at the local, national and international levels.

For each decision factor, the methodology was subdivided into two different stages. The first stage consists in the characterization of the actual situation in order to obtain a reference for the perception of the economic values. The second stage consists in the evaluation of the impacts caused by the construction of the coastal structure, considering the situation already characterized in the first phase.

A description of the variables proposed to be considered in each decision factor is presented bellow.

Changes on the Recreational Beach Use – Characterization of the actual situation

In this phase, there are some important factors to be considered:

i) The insertion of the project on the territorial management tools – this item intends to have the perception about the importance of the recreational use on a global strategy and to understand its function on the local, regional and national dynamics.

ii) The characterization of the population – In order to understand the population evolution in the last two or three decades, it is essential to implement a scale methodology, starting on a council level, then focusing on the subsequent minor levels, and finishing on the local level, including the beach users. This characterization must include birth, fecundity and death rates in order to evaluate the actual and future support capacity of the infrastructures and services. The age structure is important to understand its elderly or youthful tendency of the population.

iii) A survey to the beach users in order to evaluate the number of persons using the area in winter and summer seasons, the provenience of the local users and the transport by which they arrive and leave the zone, the reasons by which they prefer the zone, the variation of the frequency of the zone in a year, the activities practiced by each person (tourism, leisure, terrestrial sports, surf, diving…), the fruition of the existent infrastructures, the main motivation to the use of the zone (habitation proximity, existence of the beach and commercial services, the local landscape, the
possibility of the use fruition of the sea, the existence of infrastructures), the expectation about the implantation of a new project that will improve the practice of a new sport.

iv) The characterization of the economic framework - this characterization must consider the companies seeded in the council and the distribution of the working population in the primary, secondary and tertiary sectors. It is important to analyse the percentage of activities of each sector, specifically of the tertiary sector, related with leisure and Tourism, such as hotelling and restoring. It is also important to describe the employment rates and its evolution since the last ten years. This evaluation contributes to the perception of the project as a potential generator of positive economic results and its association with the actual economy.

Changes on the Recreational Beach Use – Evaluation of impacts

Considering the characterization of the actual Recreational Beach Use, the evaluation of the impacts of the new coastal structure, must consider three important factors: coast line protection, sediment recharge and control of sea conditions. To consider these factors, the following items must be followed:

i) Application of criteria to choose the project location. This must include the characterization of the local waves, specially the ones already used for specific activities such as the surf, the study of the tide regime (its direction and its diffraction points), of the dominant winds (velocity and directions), in order to evaluate the effects of the local and offshore currents, of the transport and deposition of sediment on the subtract and on the surrounding beaches. In this point, it is crucial to guarantee the control of the protection of the coast line for a more secure use.

For the specific case of artificial surf reefs, the following factors must be added:
- The region climate, which must be the most stable in order to allow the surf practice in the winter and in the summer.
- The distance between the coast and the storms origin, which must be enough great to prevent the reception of irregular and immature waves, but enough near to receive strong waves. These conditions allow the coast to receive perfect waves
- The evaluation of the existence of surf sports on the neighbourhoods, in order to guarantee the distance from these points and avoid the “crowd”.
- The region capacity to promote the reef and for the capitalization on its potential for the Tourism
- The study of the existence of other projects for the neighbourhoods, such as, museums, surf schools, coffee shops, restaurants, shops and surf material outlets, and of surf support infrastructures (Toilet, balnearies, chests) and the study of the advantages of the integration of these projects with reef, regarding the improvement of the coastal area.

Bathymetric measurements - The bathymetric measurements are very important for the choice of the place for the new coastal structure, for the definition of the structure geometry, for the numeric simulation and for the construction of the physical model. The bathymetric measurements allow the design of the new structure using software CAD 3D tool, which is then used to simulate the waves’ propagation by numeric modelling in order to evaluate the efficiency of the design, which can be adjusted until the better design be found.

ii) Application of technical criteria for the configuration of the reef - In the specific case of projects design to improve the surf, it is essential to create a very good quality wave, in order to be surfed by experienced surfers. Then, the surfability parameters must be considered: Peel Angle, Length of wave wall, Irribarren number, Surf lane, Wave
height at breaking, Wave period, Amplification of the wave height, Type of breaking. These parameters allow the
decrease of the waves’ energy reaching the coast, which is an advantage to the beach erosion reduction.

In the end of this phase, it must be possible to evaluate the possible modifications on coast protection, on sediment
recharge, on sediment transport, and on the tides, in order to preview the better design to the new structure with numeric
and physical simulation.

**Biodiversity Loss – Characterization of the actual situation**

To characterize the fauna and flora species, it is important to identify the dominant sea and earth-sea interface
species, its distribution patterns, together with its photographic illustration. It must be estimated the sea bed area covered
by seaweeds and crustaceans, and the contamination sources must me identified. The following parameters must be
evaluated to characterize the sea conditions in which occurs the species development: light, temperature, sediment
movements, turbidity, pH, hardness, dissolved oxygen, nutrients, and organic matter. The evaluation of the species
variation in a year allows the identification of reproduction cycles, in order to plan the construction of the new coastal
structure in strategic period that don’t prejudice the species development.

**Biodiversity Loss – Evaluation of impacts**

The impact analysis of the new project on the local biology development must be carried out by a specialised
biologist’s team. In order to evaluate the species development, an ecological model must be applied, that allows for the
evaluation of the fauna and flora development. In this modelling, the following factors should be considered: the length
and superficial area of the coastal structure, the habitat stability and the topography created, the structure material and
the study of preview results of other projects.

The structure and its surroundings monitoring could be a very good input for this evaluation, especially if it starts
before the construction phase and continues during this phase. The divers, who identify the species found on the structure
and on its surroundings, can simultaneously verify the correct design and placement of the structure. Submerged video
chambers can be placed in order to include a continuous monitoring. It can also be evaluated the evolution of the sea
conditions as well as the effect of the water purification by the seaweed colonization, by water quality analyses. Finally,
the carbon dioxide sequestration by the seaweed communities, which depends on its diversity and characteristics, can be
considered on the ecological modelling.

**Tourism Improvement - Characterization of the actual situation**

In this phase, it is essential to know the local infrastructures, the existent nautical sports and its practice
development, and also the perception and receptivity of different entities about the new project. Consequently, it is
important to consider the characterization of the economic activities related with Tourism and leisure, namely restoring,
Tourism, travel agencies, sports and sea, and the attractiveness of the area for commerce and services, the lodging
capacity of the council, and the evolution of Tourism in the country. It must also be considered the beach and the zone accessibility, the popularity of the surf in the area, at an international, national and local level.

For the construction of a given coastal structure, it must be carried out a **pre-public consultation** in order to evaluate its acceptance by the public. (Custódio et al. (2008)) Normally, this phase occurs after the finishing of the Environmental Impact Assessment. Thus, it is absolutely necessary to have meetings with people concerned about the project and to clarify its objectives, to get a better perception of their feelings about the project, to feel their fears and hear suggestions.

A **survey** must be carried out in order to evaluate the number and level of the surfers, their place of residence and the transport they prefer to arrive and leave the zone, the number of days that foreign surfers stay there, the type of accommodation they prefer, the reasons why they prefer this place to practice surf, how much they spend for a day, how many times they surf in a year, the opinions about the implantation of a new surf structure.

The contact with surf clubs can help in the perception about the number of partners and the number of practitioners (age, residence place, transport mean and costs, type of surfers (professional or fans), level of surfers (beginners, intermediate or advanced), period of the year which they prefer to practice, type of wave they prefer, and the existence of a stabilised surf community

**Tourism Improvement – Evaluation of impacts**

This stage of impacts evaluation must consider the analysis carried out previously in the pre-public consultation, in order to guarantee the interests of the different entities. In the construction phase, the impacts must be evaluated considering: the duration of the construction, the period of the year chosen to construct the structure and the construction time in the sea and in the earth

In the exploitation phase, the following aspects must be considered

- Development of the economy and the local activities provided by the increase of the population in the zone (investments in the restoring, hotelling and leisure facilities),
- Increase of the local touristic interest and valorization of the coast line,
- Diversification of the local uses, including the creation of conditions for the practice of other nautical activities, such as diving and fishing, as well as other nautical waves’ sports (bodyboard, longboard, kneeboard),
- The social advantages provided by the practice of sports and conviviality,
- The level of surfers that will make use of the zone,
- The beach carrying capacity for the surfers,
- The improvement of the activity of diving schools
- The possible effects of overload suffered by the local residents,
- Creation of employment,
- Transport and access infrastructures to the zone,
- Long term evolution forecasts of the age structure of the population,
- Development of the surf industry,
- The potential of the zone to become a strong surf spot,
- The potential of the zone to the development of school sports.
In the end of all phases of the methodology, the study of the proposed variables, it should be possible to conclude about the relevancy of the implantation of the project in the following items:

- The influence of the Project in the existent infrastructures and ways which depends on the carrying capacity support,
- The contribution of the project to the requalification and improvement of the coast zone, simultaneously with other projects planned to the zone,
- The contribution of the project to the strategic objectives of the council,
- The relation cost-benefit and the economic return obtained.

In the case of projects designed to the improvement of nautical sports, it is also crucial the perception about the influence on the visibility and image of the council, related with the improvement of an active life style associated with youth and health, normally connected with the practice of this type of sports.
CASE STUDY

The main objective of the construction of the artificial surf reef is to improve the wave conditions in the beach of S. Pedro do Estoril for surfers, and consequently, the economic development of Estoril. It is supposed to generate a surf wave, with international quality, for experienced surfers, in order to create the third surf spot in the council of Cascais that already has two important surf spots: Guincho and Carcarvelos.

The second objective of the construction of this reef is the protection of the coast line and the improvement of the conditions for the development of fauna and flora species.

For this purpose, the Câmara Municipal de Cascais (CMC), the Instituto Superior Técnico (IST), the Laboratório Nacional de Engenharia Civil (LNEC) and the Faculdade de Ciências da Universidade de Lisboa (FCUL) agreed in a protocol to produce the necessary studies for the development of this project including its Environmental Impact Assessment.

The area of study for the artificial surf reef in the S. Pedro do Estoril, Portugal is limited in the West end by the Neo-Gothic Castle and in the East end side by the Avencas beach and biophysical reserve. The coast is composed of 20m to 30m high cliffs with two relatively steep and narrow sandy beaches, the S. Pedro beach and the Bafureira beach.

Fig 1 – Area of study and site of the artificial reef.

The beach of S. Pedro do Estoril, see Fig. 1, is situated in Estoril, which belongs to the Council of Cascais, Portugal. It has good surf conditions for intermediate to experienced surfers, mostly during the fall, winter and spring. Historically, this is the first beach in Portugal where a community of surfers was established. Its surf club (Surfing Clube de Portugal) is 30 years old and has produced several top national surfers in the sports of surf, bodyboard, longboard and skimming.
APPLICATION OF THE METHODOLOGY

This methodology was set up with the development of the Environmental Impact Study of the Artificial Surf Reef of São Pedro do Estoril that pointed out the necessity of the development of a specific methodology for the evaluation of socio economic impacts of coastal structures.

In the following chapter, it is presented the most important aspects of the application of the methodology to the Case Study.

For the majority of the inhabitants and users of the zone, the beach of São Pedro do Estoril is the main motivation for the affluence to the place, and also its wonderful landscape framing and the fruition of the sea. This beach has a great touristic potential, namely in what concerns leisure activities.

- The analysis of the economic setting stated that there is a trend for the predominance of activities directly related with Tourism and with the building activity.
- The São Pedro do Estoril locality is the oldest surf point in the council of Cascais that has developed slowly. There is also surf industry, the oldest surf club of the country (Surfing Clube de Portugal) and a point for school surf. So, this place joins the propitious conditions to develop nautical sports such as the surf.
- The characterization of the local existent waves showed that there are four wave conditions for regular to experiences surfers. They are all situated East of the Ponta do Sal. The ex libris is the Bico wave, a long right-hander wave, with several soft sections, allowing surf rides with a length of up to 350m. This wave has been surfed consistently for more than 40 years, and for wave heights to 1 m to 7 m. The other waves are the Left and Right of Bafureira, and finally the Suicida Left wave. The S. Pedro do Estoril Coast was selected as the best place for the creation of a new wave, due to its consistent waves, producing good surf mostly in the fall, winter and spring. In the place project to the reef, the waves break in a natural reef area, rarely used by surfers since the existing surf has poor quality. The artificial surf reef is projected to “create” a new surfing wave condition, of international quality, for experienced surfers. This new wave will complement the existing waves.
- There are previsions of other projects to the surroundings such as the implantation of a submarine-museum in the coast line of São Joao do Estoril.
- The technical studies included a very detailed bathymetry data acquisition of the surf zone of the São Pedro do Estoril Coast Alves et al. (2007). This bathymetry was done, with a resolution of 1.0 mx1.0 mx0.1m. It extends up to 2.0 m above the Hydrographic Zero, corresponding to the mid-tide height. Numerical tests were performed in the situation without the reef and with different reef configurations and locations. This method allowed also the guarantee of the maintenance of different aspects related with the local and offshore currents, with the transport and deposition of sediments over the substrata and over the neighbourhood beaches.
- The identification of the existent fauna and flora species on the zone allowed the perception of a great variety of species and the inexistence of species in extinction risk. Probably, the reef will allow good conditions for the development of species but it was not possible to quantify the time between the end of the reef construction and the complete colonization of the reef, due to various factors related with the sea conditions.
- There is a strong relation between the surf and the locality of São Pedro do Estoril, where there are surfers with ages
between 5 and 76 years old that come from the council of Cascais or the surroundings councils. Many surfers make
advantage of the potential of the zone, since the development of their capacities through the attendance of surf classes, the
practitioner training, or the championship training.

- The population, employment and economic activities will benefit with the population raising (surfers and tourists) in
the zone and the inherent development of the local economy (coffee shops, bars, restaurants, parking and lodging) as well
as the creation of new services. The local economic activity will benefit with the realization of international competitive
events, which will increase the local touristic significance, in particular, in what concerns to the arrival of tourists to the Ponta
do Sal.

- The pre-public consultation was carried out in order to evaluate its acceptance of the project by the public. There
were consulted entities such as schools, surf, diving and sailing schools and clubs, environmental non-government
organizations, concessionaries placed in the area of study, enterprise and inhabitants associations, researching institutes
and labs. The surf schools and club had an important contribute to define the better place for the new structure and for its
design in order to achieve the type of wave previewed.

- It is expected a great income of people to the beach and surrounding areas, motivated by the new conditions created
by the reef, which allows the spatial and temporal dispersion of the activities and, consequently, the reduction of the “crowd”.
It is also expected that the beach will receive new surfers from other beaches of the coast, from other places of the country
or even from foreign countries. The improvement of the surf conditions will allow the realization of surf events including more
experienced surfers.

ENVIRONMENT IMPACT ASSESSMENT

The Environmental Impact Assessment of this project considered other factors, beyond the socio economy, such as land
management, geologic characterization, water and air quality, biology, noise, landscape, architectonic and archaeological
heritages. These factors were analysed together and the respective impacts identified and quantified.

Some measures will be proposed to minimize the negative impacts and other measures to improve the positive ones, and
an environmental management plan to assure that the proposed measures are implemented. We refer in this paper, the
measures proposed for the socio economy:
- The enhancement of the creation of employment
- The promotion of the use of public means of transport and of the access on foot or by bicycle,
- The divulgation and information about the project
- The monitoring of the reef effects on the local conditions, in the coast line and on the bathymetry
- The monitoring of the local biology development through a specialized team of biologists
CONCLUSIONS

This paper describes a methodology for the evaluation of socio economical impacts of the construction of coastal structures which proposes the consideration of three main decision factors: Changes on the Recreational Beach Use, Biodiversity Loss and Tourism Improvement. The methodology was designed in order to allow the conclusion about the viability of the project considering the carrying capacity support of the existent infrastructures, the necessity of requalification and improvement of the zone, the strategic objectives of the council and the economic return obtained. To the specific cases of projects design to improve nautical sports, the methodology also allows the perception about the influence on the visibility and image of the council, related with the active life style associated with youth and health, normally connected with the practice of this type of sports.

The Case Study consists on an artificial surf reef on São Pedro do Estoril Beach and is a specific case of a coastal structure design to improve the surf conditions in the coast of Estoril. The Environmental Impact Study of this reef pointed out the necessity of the development of the presented methodology.

The application of the methodology to the Case Study pointed out some relevant aspects that will contribute to its success in the construction and exploitation phases.

We also describe some measurements in order to improve the socio economic impacts of its implantation.

Finally, we propose this methodology as an orientation guide to the future realization of Environmental Impact Studies of coastal structures.

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