Carbon sinking through coastal landscapes: Identifying opportunities for the port of Sines, Portugal

Lucas Marinho [1], Conceição Freire[2] and Teresa Batista[3] *

[1] MED – Mediterranean Institute for Agriculture, Environment and Development, Universidade de Évora, Évora, Portugal. lucas.marinho@uevora.pt
[2] Chaia - Centro de História de Arte e Investigação Artística, Universidade de Évora. mcmf@uevora.pt
[3] MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Institute for Advanced and Research, University of Évora, Évora, Portugal. mtfb@uevora.pt
* Correspondence: mtfb@uevora.pt

Abstract: The 2050 European Union's goal of carbon neutrality involves intervening to decarbonise various key sectors in the member states, such as maritime ports. The aim of this study is to develop a methodology of analysis for the port of Sines' landscape, in order to find ways of reducing its carbon footprint through a carbon capture project by its own landscape. The study is based on the data regarding the carbon footprint for which the port administration is directly responsible, as stipulated by scopes 01 and 02 of the Greenhouse Gas Protocol. Next, it is proposed the analysis of the landscape context at three scales (Port jurisdiction, Municipal and Municipal surroundings areas), using GIS tools for land use and occupation parameters and landscape units, as well as landscape planning standards. This characterisation allows the location of ideal zones for implementing emission offsetting measures. The possibility of using vegetation is emphasised as a way of enhancing local ecosystems and reducing the port's carbon footprint, in which it can be chosen based on its ecological and cultural relevance within the context of Sines, with the intention of having a landscape design that is consistent to and active against climate change.

Keywords: Landscape; Carbon Footprint, Decarbonization; Port of Sines; Carbon sink

1. Introduction

The European Union aims to become greenhouse gas neutral by 2050 as a way of slowing down the consequences of climate change. The goal is a central part of the European Green Deal, which aims to achieve efficiency in the use of natural resources, linked to economic development [1]. However, there are many challenges to achieving this goal, which involve the energy transition and the decarbonisation of various sectors.

In order to decarbonise efficiently, it is necessary to thoroughly study the different emitting agents within each activity. Understanding the origins of emissions and the greenhouse gas (GHG) profile associated with activities is a fundamental step in planning the measures that organisations must take to make the energy transition a success. This study, known as the Carbon Footprint, seeks to understand the trail of pollutants derived from their activities, that is, the contribution left in the atmosphere, which consequently aggravates the climate change conditions faced worldwide [2].

Within the European decarbonisation target, an important sector to consider is ports. After all, the complex industrial activity associated with the movement of goods and other services offers many opportunities for significantly reducing GHG emissions. Ports

themselves encompass key activities for the economy of the countries and regions in which they are located, because their use is in affinity with the industrial and energy sectors, and they can contain such facilities in their own infrastructures.

Maritime ports, being located in areas that are sensitive to climate change, such as coastal strips, can be seriously affected by rising sea levels and other climatic risks, which can jeopardise the functioning of operations and the performance of the sector. In addition, port facilities are located in a context of transition between terrestrial and marine ecosystems, and are often associated with freshwater bodies such as estuaries and lagoons. These factors aggravate the environmental impact of their infrastructure and can affect the quality of pre-existing natural processes. Therefore, an efficient energy transition and its consequent decarbonisation are viable solutions for maintaining ports and the landscape in which they are located [3].

In order to develop the port sector with environmental responsibility in the face of decarbonisation targets, ports need to be adapted to the landscapes that host them. This can be done through carbon offsetting measures which, by promoting port decarbonisation, also improve the quality of local ecosystems [4]. One of the main compensation measures in the context of decarbonisation is carbon capture, which consists of retaining carbon dioxide (CO_2) from the atmosphere through artificial or natural processes that store it or transform it into other elements [5].

Notably, the oceans are the planet's main carbon sinks, where, through contact between the water layer and the atmosphere, various chemical and biological processes act to capture the element. The oceans alone have captured around 30 per cent of the carbon dioxide emitted by human activities [6]. In addition to marine processes, terrestrial processes account for another important share of carbon capture, accumulating around a third of the carbon emitted by human activities each year. On land, vegetation and soil are mainly responsible for absorbing and retaining the element, where plants capture CO_2 through photosynthesis, transforming it into oxygen and other products [7]. Besides natural cycles, new artificial possibilities for capturing CO_2 have been developed, such as Direct Air Capture (DAC). However, the technology needed for artificial carbon capture is not yet available to operate on the scale required, mainly due to the high cost of implementation [8].

In the port sector, various initiatives have been proposed by different organisations and authorities to reduce their own carbon footprint. The Port of Rotterdam in the Netherlands, for example, proposes storing CO_2 in underwater caves in the North Sea. The programme, called Porthos, is part of the national targets to reduce emissions by 55% by 2030, with 1990 as the base year [9]. Another project that has taken on port decarbonisation is '*Peiraos do Solpor*', in the Port of Vigo, Spain. This initiative proposes intervention in existing port structures by adapting them to the natural environment so that they are integrated into the ecosystem. This is done in order to create habitats that once existed in the area and were replaced by the port facilities. The programme aims to reduce its carbon footprint by capturing CO_2 through improving the quality of marine ecosystems and their associated services [10].

The examples cited above reinforce the contemporary effort to combat climate change, where maritime ports play an important role in decarbonisation and energy transition. Designing landscapes for decarbonisation should be a crucial stage in the development of ecologically and economically balanced societies.

2. Materials and Methods

This work set out to investigate possibilities on port decarbonisation in the context of Sines, on the Alentejo coast in Portugal, where it sought to understand the fundamental

role of the landscape as an actor in carbon capture and balance between the forces acting on that territory. Sines was chosen as the case study because it is an important port for the region, where its location concentrates diverse landscape and economic values, and is key to identifying potential intervention techniques for the port landscape, with the intention of developing compensation and carbon capture measures.

The study's methodology aims to analyse the carbon footprint data for the port of Sines, developed as part of the *Agenda NEXUS* study, which applied the principles stipulated by the GHG Protocol and IAPH - Carbon Footprinting to the port of Sines. The methodology used by the study classified emissions into different scopes, based on their emitting activities and the degree of responsibility for emissions in relation to the port of Sines. Therefore, it was chosen to work with data from scopes 1 and 2, as they represent the Carbon Dioxide Equivalent (CO_{2eq}) emissions directly associated with the port activities of the Port of Sines Administration (APS) [11].

After collecting the carbon footprint data, a landscape analysis of the area is proposed based on the 'Site Specific' theory, in which can be carried out on three scales: A local one, in the Area of Jurisdiction of the Port of Sines (AJAPS); an adjacent one, in the Municipality of Sines; an extended one, considering the neighbouring municipalities [12]. The aim of this characterisation is to understand its existing elements, using as a reference the Landscape Units, ecological components and the Land Use Map (COS 2018). This reading is carried out in order to outline and understand the fundamental structure of that landscape.

The next step is the analysis of the legal documents surrounding the area, which determine the basis for its use and occupation, such as the Municipal Master Plan of Sines and of its adjacent municipalities, as well as the maps of areas classified for nature protection. This stage reveals the planning of that landscape and the aspects it considers for its planning and management.

The interpretation of the landscape characterisation maps and their legal zoning plans makes it possible to compare and cross-reference data, using GIS softwares to compute parameters and determine areas with a suitable vocation for implementing land use dedicated to carbon capture.

The following stage involves developing scenarios in which suitable plant species are proposed for each potential zone demarcated, with the aim of obtaining carbon sequestration values based on the vegetation proposed for the three landscape scales. The plant species should be chosen in order of their historical and ecological characteristics, so that their implementation could also reinforce the heritage value of the landscape in which the study takes place.

Finally, the study aims to summarise the results of the carbon footprint of direct emissions from the port of Sines, presenting them in relation to the amount of CO_2 captured by the landscape, as it stands today and as it could be with the proposal presented in this study.

3. Conclusion

This study sought to propose a project methodology that involved aiming for the resilience of the port of Sines landscape, finding in that regional territory and in its natural environment the stimulus to face climate change and take on decarbonisation, through reinforcing its agricultural activities and natural ecosystem services.

In addition, by identifying underutilised and degraded areas, the proposal aims to outline the implementation of new uses that may enhance the region's ecology and natural heritage context. In summary, this work intended to develop a methodology that