BUILDING WITH NATURE OPPORTUNITIES

For the San Antonio Port Expansion Project

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Colophon

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Preface

This research is carried out as part of the course CIE4061-09 Multidisciplinary Project, Civil Engineering Consultancy Project (2021/22), part of the Master Civil Engineering at the TU Delft. When we were informed by the TU Delft about the opportunities to carry out a project abroad, many different interesting opportunities came across, however, one country stood out. Martijn Onderwater (Senior coastal engineer at ARCADIS) introduced us to Mauricio Reyes (Associate Professor at Universidad de Valparaíso), who gave us an elaborate overview of potential projects in Chile. When we found out that Boskalis was involved in one of the projects, we got in contact with Bart Rumes (Area Manager of South America). He accepted our proposal for a Building with Nature solution for the port of San Antonio. This research is based on the work of the previous workgroup from TU Delft, who did a study into creating awareness of Building with Nature in Chile.

We would like to express our gratitude to Mauricio Reyes and his colleague Patricio Winckler (Académico and consultor at the Universidad de Valparaíso) for their warm welcome in Chile. They not only introduced us to the culture, food and wines of the country, their specialized knowledge was essential to the success of our project. We felt at home during our time in Chile thanks to their hospitality. We would also like to thank Loreto Trigo, who helped us when attending the public meetings in San Antonio and with translation.
We are also grateful to our university supervisors, Martijn Onderwater and Shehab Elmohr (Junior Lecturer at the TU Delft), for their feedback and advice. Without them, this project would not have been possible. We want to thank the team at TU Delft for giving us this opportunity.
Finally, we want to thank Boskalis and Bart Rumes for their financial support. We are grateful to Bart and Annouk Rey (Coastal Engineer at Boskalis) for their supervision, help and expertise. Their knowledge was invaluable to us.

This project was more adventurous than we initially anticipated, and we learned a great deal about the aspects of the field. In retrospect, it has been a highly valuable and memorable experience for us.

December 2022, Delft

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Acronyms

ADCP Acoustic Doppler Current Profiler. vii, 8, 18, 19, 24, 51, 52, 55, 92

AOC Atlas de Oleaje de Chile. vii, ix, 17, 47–51, 53, 91, 92, 141

DyR Parque Del Pacífico (*alternative name*). 14, 34

EIA Environmental Impact Assessment. ii, 3, 5, 12, 30, 31, 40, 44, 82, 90, 91

EPSA Empresa Portuaria San Antonio. v, 25–28, 30–38, 40–44, 46, 81–84, 86, 87, 119

ERA European Centre for Medium-Range Weather Forecasts Re-Analysis. ix, 17, 47–49, 51, 141

GEBCO General Bathymetric Chart of the Oceans. 8, 21, 138

MOP Ministerio de Obras Públicas. 33, 38

MSL Mean Sea Level. 74

MTT Ministerio de Transportes y Telecommunicaciones. 26, 106

NGO Non-Governmental Organisation. 25, 28

PGE Puerto a Gran Escala (Large scale port). viii, 1, 2, 4, 12, 24, 28, 30, 39, 43, 46, 70, 73, 75, 76, 89, 90, 93

SEA Servicio de Evaluación Ambiental. v, 26, 28, 31, 32, 34, 37, 38, 44–46, 86, 90, 106

SEIA Sistema de Evaluación de Impacto Ambiental. 26–28, 30, 31, 34, 90, 106

SHOA Servicio Hidrografico Oceanografico de la Armada de Chile (Hydrographic and Oceanographic Service of the Chilean Navy). vii, 21

SMA Superintendencia del Medio Ambiente. 26, 106

SWAN Simulating WAves Nearshore. iv, 6–8, 10, 24, 47, 51, 61, 66, 91, 92

SWOT Strengths, Weaknesses, Opportunities, Threats. ii, 42, 46

TEU Twenty-foot Equivalent Unit. 1

TOWS Threats, Opportunities, Weaknesses, Strengths. x, 42, 43, 46

1 Introduction

1.1 Project context

International trade is an important driver of Chilean economic development. 95% of international trade is maritime, making the country's port infrastructure vital. The Valparaíso region in Chile currently has two container ports: Valparaíso and San Antonio, the latter one displayed in Figure 1a. These two ports are the two largest in Chile and serve the central Chilean hinterland, an area which includes the capital Santiago and is responsible for 60% of national GDP and is home to 66% of the population (Michea, 2015). According to projections, container freight demand is growing fast. 2.68 million TEUs were handled by the Valparaíso region in 2021 (Puerto San Antonio, 2021) whereas projections for 2033 predict a demand of 7.25 million TEUs (Puerto San Antonio, 2013).

To cope with these projections and avoid port congestion, the former president of Chile, Michelle Bachelet, awarded the Port of San Antonio in 2018 with state support for their planned port expansion (PULSO, 2018). The expansion involves the construction of a new seaward container terminal, the Puerto a Gran Escala (PGE). The expansion plans shown in Figure 1b are detailed in the port authorities' 2033 master plan (Puerto San Antonio, 2013) and will provide an additional capacity of 6 million TEUs per year. The expansion involves an investment of 3 billion euros (IKONS ATN, 2020) and will consist of a 3900-metre-long breakwater and 13 million cubic metres of interior dock dredging which will be used to fill the new terminal.

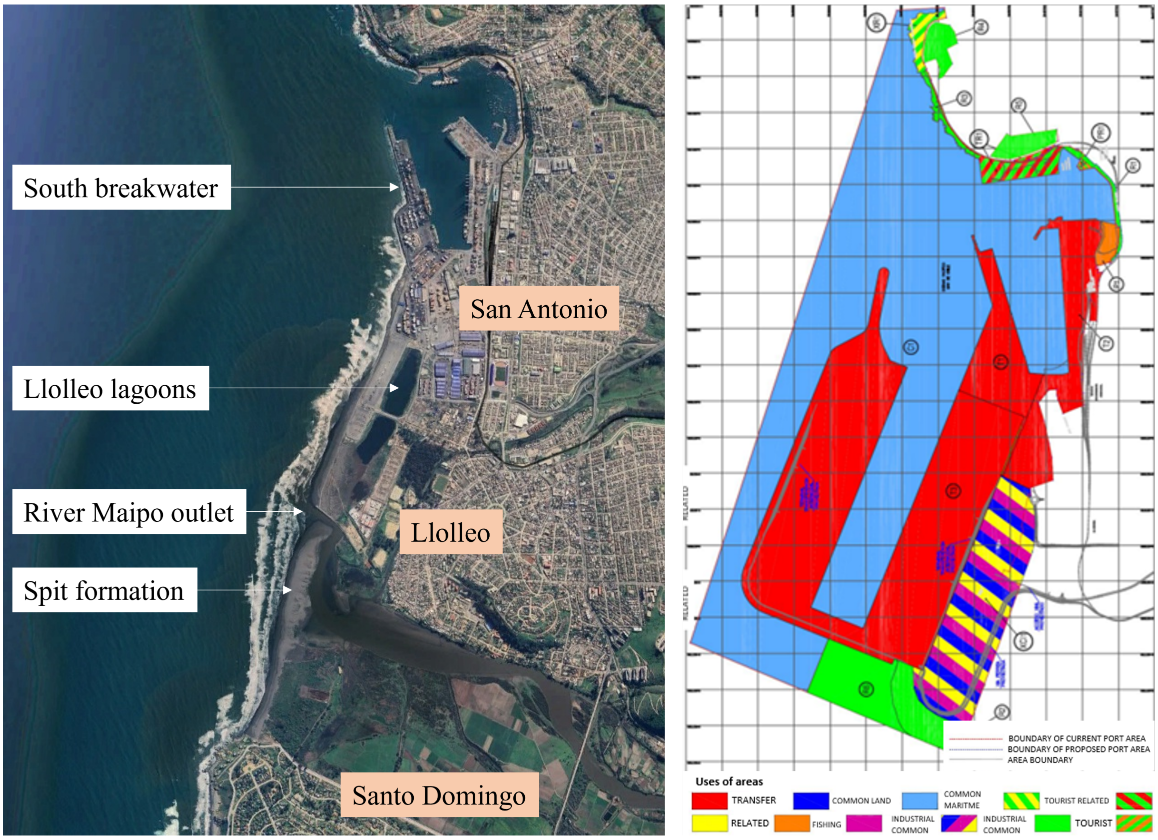


Figure 1: (a) Satellite view of San Antonio (Google Earth, 2022) (b) The port's planned development for the year 2033 (Puerto San Antonio, 2013)

However, this aspiring project has been met with heavy resistance from the public because of its potential implications for nature, the environment and the livelihood of the people of San Antonio. It has also been questioned over the extent to which different industries and areas will be safeguarded, how this can be assured and how the people of San Antonio will actually benefit from such a mega-project in practice. As such, the possibility of a better solution, based on Building with Nature principles, is explored. The solution aims to incorporate the voices of all the main parties affected by the project works, while still fulfilling the requirement for increased capacity in the future. Something of great importance not only for the people of San Antonio, but the whole country.

1.1.1 Previous research

As briefly indicated before, current expansion plans appear to use conventional construction methods which are often costly and cause damage to the environment. The Chilean government has shown interest in the Building with Nature program which provides an alternative to these conventional solutions. It aims to create nature-based solutions for water-related infrastructure which harnesses the forces of nature. A previous multidisciplinary project report hypotheses a way in which Building with Nature concepts can be applied to the expansion project at Port of San Antonio with the general aim of using longshore sediment transport to reduce required dredging volumes (Batenburg et al., 2019). They proposed a phased construction as shown in Figure 2. Step one involves using perpendicular groynes causing sediment accretion at the location of the land side of the PGE terminal. Step two proposes constructing the perpendicular port breakwater section. This breakwater causes accretion to the South side of the breakwater. Step three uses this accreted sediment for terminal reclamation after the parallel section of the breakwater is built. Finally, step four involves any necessary dredging of the port basin, the dredged sediment can also be used for terminal reclamation. The proposed Building with Nature solution for the port expansion will be modelled to analyse its feasibility. Alternative solutions will also be proposed based on the steps outlined in the previous research.

Figure 2: An example of a Building with Nature alternative applied to the expansion of the Port of San Antonio (Batenburg et al., 2019)

1.1.2 Research gap

In order to determine the feasibility and the timescale of a potential Building with Nature solution, first, the approximate sediment transport volumes must be known. A Building with Nature solution appears to be feasible as proven by significant accretion at the south side of the current port breakwater over the last 100 years. The Maipo river located south of the port (Figure 1) provides a lot of sediment influx, particularly during high spring river discharges. An example of the littoral transport of sediment from the river can be seen in Figure 3. The sediment supply from the river has however decreased in the last couple of years due to the flow reduction of the river caused by climate change (CR2, 2021). The sediment transport along the coast is directed from South to North and does not exceed the North tip of the southern breakwater of the port (Figure 2) due to a submarine canyon. Port of San Antonio's master plan document (Puerto San Antonio, 2013) references multiple papers discussing sediment transport at Port of San Antonio including qualitative sediment transport distributions identifying areas of expected erosion, sedimentation and equilibrium. However, no papers publicly available seem to give a quantitative answer to sediment transport required for evaluation of the timescale of a Building with Nature solutions. Besides Building with Nature alternatives, knowledge of quantitative sediment transport volumes can also be useful for anticipating the required maintenance dredging of the new port basin.

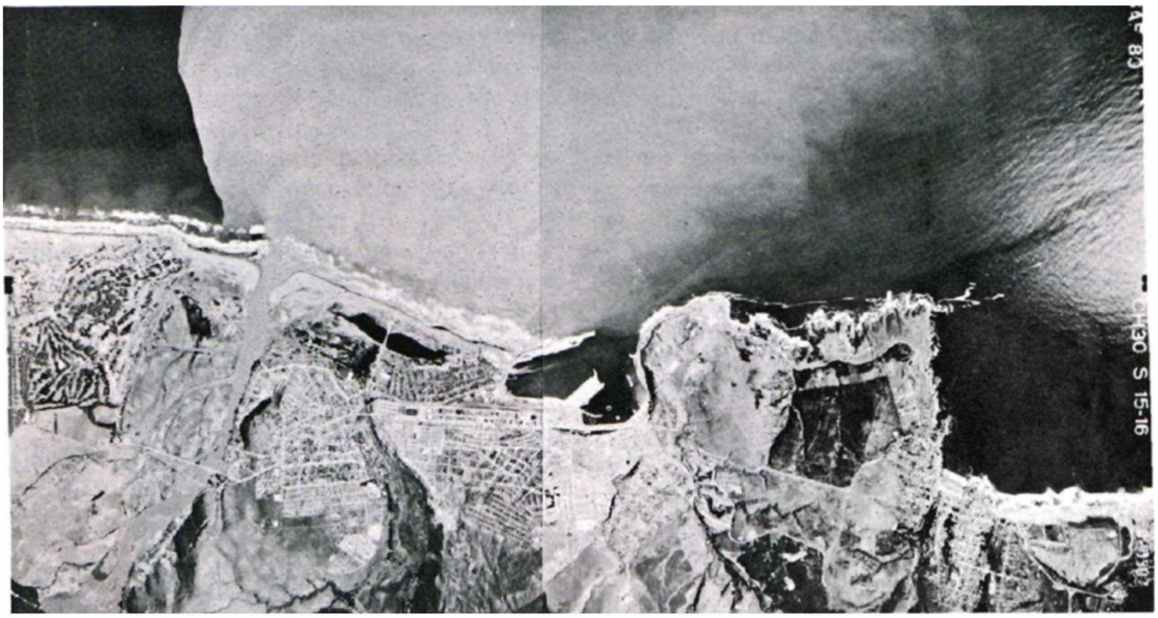


Figure 3: Areal picture of the littoral transport of the sediments carried by the Maipo River towards the north (Canto et al., 1983)

Secondly, the social climate surrounding the area where project works are planned needs to be studied to understand what should be incorporated in a potential Building with Nature solution. Based on the directory entries of the port authority on the website of the environmental impact assessment services, the design for the expansion project has already been revised due to problematic environmental aspects and issues with the public of San Antonio (SEIA, 2020). Therefore, in order to get a clear picture of the situation at hand and how these conflicts can be affected by the implementation of the potential Building with Nature solution, the entries in the port's directory on the environmental impact assessment services' website need to be more thoroughly studied, with specific attention on the Environmental Impact Assessment report of the project works. Furthermore, there seems to be very limited direct information on the sentiments of the public, i.e., that can be obtained without the context provided in the anthropological studies of the EIA report. Thus, these need to be closely studied as well, preferably by getting first-hand accounts from the public's perspective.

1.2 Research objective and questions

The project's main objective is to determine the feasibility of a Building with Nature solution for Port San Antonio's planned seaward expansion. The objective will be tackled from both a technical and social perspective based on the Building with Nature philosophy as introduced in Section 1.1.1. To determine the technical feasibility of a Building with Nature solution, the morphological system surrounding the Port of San Antonio must be understood. Following this understanding, the gross sediment transport volume for the current situation can be determined quantitatively. This knowledge can be used to predict the effects of interventions used for the creation of the PGE.

To determine the social feasibility of a Building with Nature solution the social and political climate of the project area will be explored in order to identify issues and conflicts that could prevent the success of a Building with Nature solution. After these issues are identified, advice on what approach to take in order to minimise the (negative) effects of these issues in the process will be given, followed by the development of alternatives based on what is feasible and on the social climate.

1.3 Report outline

The report is outlined as follows: the methodology for the social and technical part is explained in Chapter 2. Furthermore, the limitations and assumptions regarding the methodology are elaborated on in this chapter. In Chapter 3 Background Information and Data Gap, the reader gets informed about the acquired data used for the different models. Chapter 4 Network Analysis, contains the network analysis. It explains the stakeholder analysis and provides a power-interest grid. Besides the stakeholder analysis, the concerns of those stakeholders are explained and analysed. In Chapter 5 Model Set-up and Validation, the offshore wave and tidal data is compiled to the nearshore and validated. Delft3D was used to compile this data at the nearshore. The nearshore data provides the basis to simulate the current, historical, and future coastline by using Unibest. Chapter 6, Building with Nature alternatives, provides different types of alternatives, which have been generated based on the results of Chapter 4 and 5. A multi-criteria analysis (MCA) grades the alternatives in Chapter 7. The last two chapters, Chapter 8 and 9 provide the reader with a discussion, conclusion and a recommendation.

2 Methodology

In this chapter, the methodology of the social and technical study will be elaborated. Although these parts of the research have their own methodology, the alternatives will be drawn up combining the knowledge gained from both the social and technical study. Furthermore, the alternatives will be evaluated based on technical and social criteria using a weighted Multi-Criteria Analysis.

2.1 Methodology - Social

The aim of the social study is to make sure that the proposed alternative is the best possible solution for the setting of the project and the people affected by it. In order for the different views and requirements of the stakeholders to be fully addressed with the new, proposed alternative, context is needed. By context, the creation of a full overview of the complete situation regarding the port expansion project is meant. Considering that there are a lot of tensions surrounding the project, it is necessary to identify key issues (Bryson, 2004) to tackle the proposed alternatives and to suggest ways for improving the environmental evaluation process of the project, which includes input from the public. In order to construct a full view of the situation and compile the necessary information to create context, it became clear from the beginning that two sides had to be explored: that of the port, the project undertaker, and that of the external stakeholders, mostly made up of stakeholders from the public, the resistance to the project, in order to understand why there are two clashing sides.

First, in order to obtain information about the expansion plans and the potential relevant stakeholders for the selected project scope, the documents submitted by the port for environmental assessment by regulatory bodies were examined. These documents were the most detailed description of the planned project works available and included studies or information about all technical and social parts affected. In order to get more insight into the tensions between the port and the public (based on some small indications in the Addendum of the main document of the EIA), a meeting was set up with the port.

After this meeting, a general idea of the project and the political tensions were finalized. With the relevant stakeholders now identified, the next step was to complete the missing information, validate the initial analysis of the relevant stakeholders, and most importantly, gain insight into the other perspective, that of the public. For this reason, public meetings organized by regulatory bodies for the port to give explanations and answer questions regarding the updated Addendum were attended. The goal of attending these public meetings was to gain insight into the other, missing perspective of the public first-hand. Since there is currently a lot of tension between the public and the port, it was decided that it would be best to attend these meetings instead of trying to set up interviews with members of the public that represent different stakeholders because, (1) in an interview, assuming that it was possible to set up, there would be no guarantee that the interviewee would give sincere answers, not affected by fears over how their life can be affected if the person interviewing them is someone from the port undercover, (2) it was guaranteed to get sincere reactions from the public during the meetings, where all relevant stakeholders would be present at once and (3) because such meetings also give more insight on how the port is attempting to gain public trust and how the information is distributed. At the end, after context was gathered, a literature study was conducted for identifying the type of governance at hand and for suggestions for handling the process in a better way, so that the tensions subside.

The results of the social and technical studies were combined to develop different alternatives for the expansion of Chile's Port of San Antonio. These alternatives were evaluated in Chapter 7 using a Multi-Criteria Analysis (MCA) to determine their performance. MCA, also known as the Weighted Sum Model (WSM), is a popular method for evaluating alternatives (Triantaphyllou et al., 1998). Criteria to judge alternatives was carefully formulated considering all relevant social and technical aspects whilst ensuring no overlap. The MCA then assesses the importance of different criteria and evaluates alternative performance in each criteria from which the best alternative is determined.

2.2 Methodology - Technical

The aim of the technical part of this study is to create technically feasible 'Building with Nature' alternatives for the San Antonio port expansion as a solution to social issues.
In order to create Building with Nature alternatives, it is important to understand the natural system in the project area. Part of the natural system is the morphological interactions between the Maipo river and the long and cross-shore currents. By understanding the morphological system, alternatives are recommended to use the sediment in a potentially beneficial manner.

Due to the complexity of sediment transportation, computer models are used to simulate morphological behaviour. Three different time frames are modelled:

- 2010 - 2020: Simulating the current situation. Currently, the coastline appears to be in equilibrium. This model gives insight into the current longshore transport volumes and is used to calibrate parameters describing the waves and the transport.
- 1912 - 1925: Simulating historic development of the coastline after the construction of the first breakwater, as shown in Figure 4. This model is used to calibrate the sediment discharge relation of the river and the chosen model parameters for that time.
- 2025 - Onwards: Simulating the future development of the coastline after the execution of the port expansion. This model is used to implement different alternatives to the port expansion project.

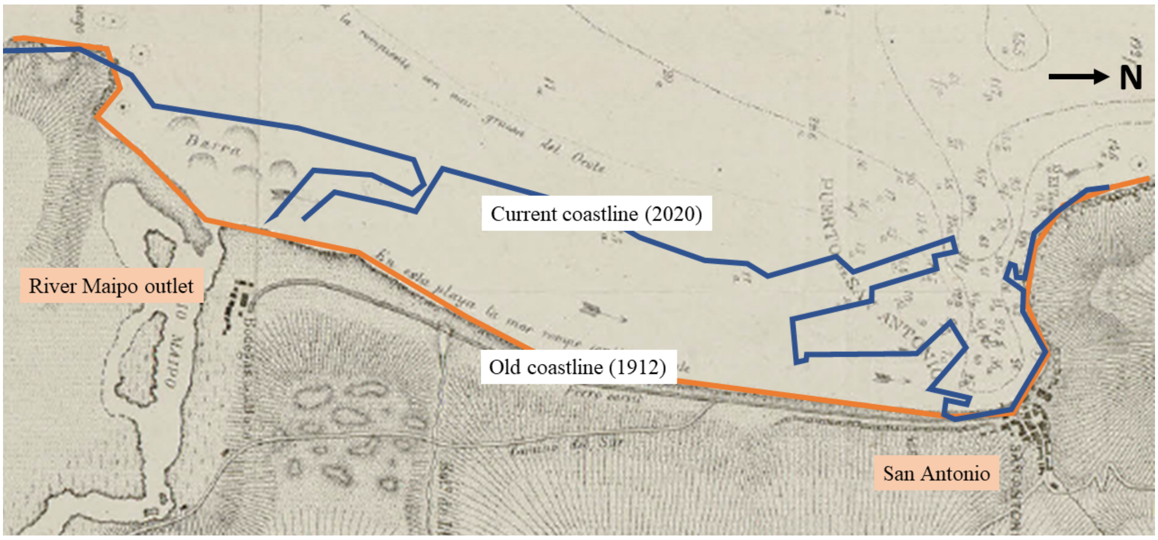


Figure 4: Observed development of the coastline from 1912 onward (original in Appendix A.1)

For every time frame, the modelling process can be split up into four different sub-models:

- Wave propagation model: Simulating offshore waves to nearshore using SWAN.
- Tidal model: Simulating tidal water elevation and horizontal velocities using Delft3D-FLOW.
- Longshore transport model: Simulating the relation between the longshore sediment transport and the orientation using the nearshore waves and tides using Unibest-LT.
- Coastline dynamics model: Simulating and visualizing the shoreline development using the longshore sediment transport relationships with Unibest-CL.

The four different sub-models, showing the most important input data per model are visualized in Figure 5. An introduction to the applied computer models, the input data, and the limitations corresponding to the models are given in the sections below.

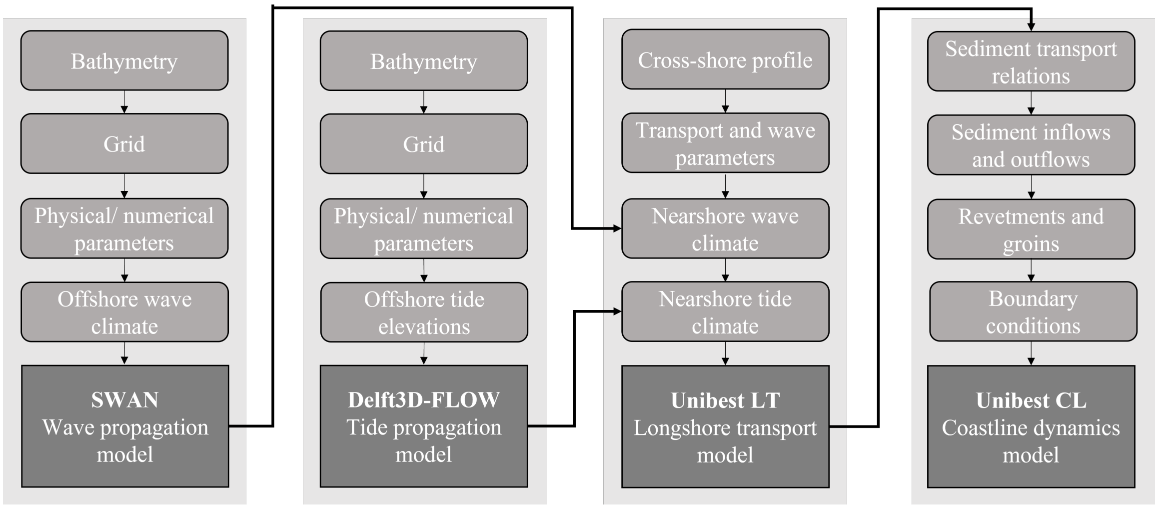


Figure 5: Schematization of the methodology of the modelling process

2.2.1 Wave propagation model (SWAN)

In order to understand the morphological behaviour of the current and historical situations, wave conditions in the nearshore project area must be known. However, wave data in the project area is limited. Therefore the propagation from known offshore wave data to the nearshore project area was modelled. The propagation was modelled using Delft3D-WAVE which uses the third-generation SWAN model. SWAN was selected as it uses state-of-the-art formulations, is applicable to the required domain size, and considers all relevant processes.
The Delft3D-WAVE user manual (Deltares, 2022c) explains that the SWAN model is based on the discrete spectral action balance equation. In this study, the model was run in its fully spectral formulation and includes the physical phenomena of refraction due to depth, dissipation due to whitecapping, bottom friction, diffraction, and depth-induced breaking. The SWAN model requires the input of:

- Computational grids
- Grid bathymetries
- Boundary conditions

Computational grid
Offshore data nodes are located approximately 145 km offshore. Due to this large propagation distance, three nested grids were used to achieve the required result detail in the project area, whilst being computationally efficient. All three grids are rectangular and are used for the computation of both the current and historical situation.

Grid bathymetry
Each grid was assigned a corresponding bathymetry file with the finest nested grid requiring more detailed bathymetry. Bathymetry data were created via triangular interpolation of raw bathymetric data gathered from various sources; namely, satellite data, GEBCO, Google earth, nautical charts, and Navionics, further explained in Section 3.2.6. Different bathymetries were created for both the current and historical situation.

Boundary conditions
The wave climate was modelled using a number of stationary wave conditions each with a probability of occurrence. The conditions were created using statistical offshore wave data sourced from both the ERA5 database and the Chilean Atlas. The raw wave data was split into clusters with ranges of significant wave height, peak period, and mean direction. Average values of each wave parameter and the probability of occurrence for each cluster were calculated to form the wave conditions. Each condition was individually applied and propagated from the model's seaward boundary.

After the above data was gathered, physical parameters, numerical parameters, and output locations were specified and the model was run. The model was calibrated using time-series data of significant wave height, peak period, and peak wave direction recorded by two ADCPs near the mouth of Port San Antonio.

2.2.2 Tidal model (Delft3D-FLOW)

To understand the morphological behaviour of the current and historical situations, the tidal elevations and horizontal velocities must also be known in the project area. The tidal influence was modelled using Delft3D-FLOW. The user manual (Deltares, 2022b) explains that the model solves the Navier-Stokes equations for an incompressible fluid under the shallow water and Boussinesq assumptions.

In this study only tidal forcing was applied, therefore a 2D, depth-averaged approach was used as fluid is vertically homogeneous. More complex 3D flows may exist in the vicinity of the submarine canyon or due to stratified flows near the River Maipo mouth. However, this requires additional research and is not necessary for this short preliminary morphological study. Like the SWAN model, Delft3d-FLOW also requires the input of:

- Computational grids
- Grid bathymetries
- Boundary conditions

Computational grid
Tidal boundary conditions were retrieved from the TPXO 7.2 global tidal model which uses a coarse grid 0.25-degree grid. These tidal conditions should be applied to a large domain. Therefore, three nested grids were used to achieve the required detail in the project area.

Grid bathymetry
The large computational grid is the order of 500 km wide, thus bathymetry mainly from GEBCO is used. For the more detailed computational grids, bathymetric data from satellite data and Navionics were used.

Boundary conditions
The flow was forced by the tide at the open boundaries in the form of water surface elevations as it is the data most easily available. A representative month was modelled to gain insight into tidal elevation and horizontal velocity magnitudes in the project area.

2.2.3 Longshore transport model (Unibest-LT)

The longshore transport is calculated using the Longshore Transport (LT) module of Unibest-CL+. The LT module calculates the longshore currents and sediment transport induced by the tidal and wave forcing on a specific coastal cross-section.

The Unibest manual (Deltares, 2022a) explains that the model uses a random wave propagation and decay model to transform offshore wave data to nearshore. During this process, the model takes into account processes such as shoaling, dissipation due to wave breaking, bottom friction and wave energy changes due to bottom refraction. To do this, the model makes use of the momentum equation to derive the longshore current distribution across the different beach locations, called transport rays. In the momentum equation, bottom friction, the gradient of the radiation stress and the tidal surface slope alongshore is taken into account.
An LT model consists of one or more transport rays. The input parameters needed for these rays are divided into different sections. As shown in Figure 5, the inputs to the LT module are as follows:

- Cross-shore profiles
- Transport coefficients
- Wave coefficients
- Nearshore wave and tide climate

In addition to the input parameters that must be defined in each LT module, the orientation angle of the coast and the active profile height should be specified. The height of the active profile is used to estimate the rate at which the coastline retreats or expands. The active height is influenced by different factors, such as the wave climate, bathymetry and the length of the time period. A first estimate of 2 or 3 times the significant wave height is used as a rule of thumb for the active profile height.

Cross-shore profiles
In the cross-shore profile module, a cross-section of the coast at the location of the defined ray can be loaded into Unibest. A grid can be automatically generated or manually if the focus needs to be on certain parts of the cross-shore profile, for example near the shoreline. Two more x-points need to be defined; the dynamic boundary and the truncation transport. The dynamic boundary is the point where the profile is split between the dynamic and static part (where no transport takes place). The truncation transport point defines until what location the longshore transport will be accounted for in the total transport.

Transport coefficients
The LT model has different sediment transport formulae available to select. For this project only the Bijker (1967, 1971) formula is considered since the sediment in the area is mainly sandy and Bijker has proved to be quite reliable in situations with relatively small (tidal) velocities. For the formula, different grain size diameters need to be known, such as the D_{10}, D_{50} and D_{90}. The fall velocity of the sediment is an important factor for the formula in which suspended sediment is considered. Additionally, the porosity and the sediment and seawater density should be specified.

Wave coefficients
As Unibest makes use of a built-in wave model, different coefficients are needed for wave breaking, bottom friction and bottom roughness. For wave breaking these parameters are the coefficients γ and α. For bottom friction, this is the coefficient f_w and for bottom roughness k_b.

Nearshore wave and tide climate
In the wave-current module, the nearshore tide and wave conditions are specified at the seaward end of the cross-shore profiles. The wave conditions are computed with the SWAN model and include the parameters for water level set up (H_0), significant wave height (H_s), peak wave period (T_p), wave direction and occurrence of the wave conditions. The tidal climate includes the water level excursion, depth-averaged horizontal flow velocity of the tidal current, the depth at the reference location and the occurrence of every tidal condition, computed with Delft3D-FLOW.

Output
When all parameters mentioned have been specified, the LT model can be run to create the transport rays. This produces a relation between the coast angle and the longshore sediment transport, a so-called S-Phi curve, at the specified location. The total longshore transport Q_s is calculated for all wave-current scenarios at different coastal angles using the following formula (Deltares, 2022a):

$$Q_s(\theta) = c_1\theta_r \exp{(-c_2\theta_r)}^2 \quad (1)$$

$$\theta_r = \theta - \theta_e \quad (2)$$

Where:

- θ_r Relative coastline angle with respect to the equilibrium coastline orientation
- θ Actual coast orientation
- θ_e Equilibrium angle for which no longshore sediment transport occurs

The coefficients c_1 and c_2 are determined by the model, which is stored in a transport ray file, which contains the shape of the coastal profile, including the coastal angle, the parameters needed to compute the S-Phi curve and the distribution of the sediment in the cross-shore direction of that specific location. These transport rays are the main input to the Coastal Dynamics model discussed next.

2.2.4 Coastal dynamics model (Unibest-CL)

The shoreline propagation is calculated using the Coastal Dynamics (CL) module of Unibest. In the Unibest-CL module, the ray files generated previously in the LT model will be used to simulate the accretion or erosion of the shoreline as a function of time. Unibest linearly interpolates between each specified ray such that the transport functions do not have to be given at every grid point.

At the start of the CL model, a background is loaded into Unibest, which is a georeferenced satellite image, using the UTM coordinate system.
Unibest makes use of a curved x,y system for the coastline, where the x-direction is the coastline, and the y-direction is the profile, perpendicular to the coastline. The coastline should not be drawn in too much detail to prevent the perpendicular lines in the y-direction from overlapping. The number of grid points between each basic point can be chosen such that the grid will be finer at locations of more importance. An overview is shown in Figure 6.

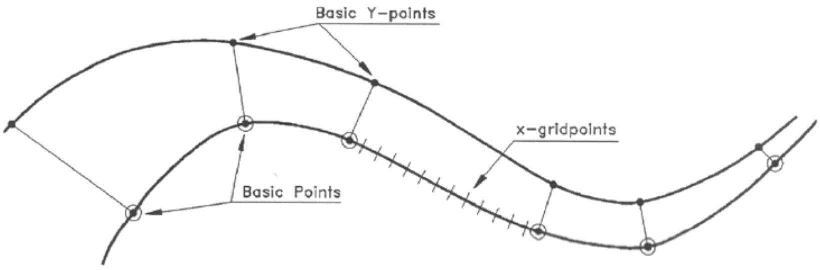


Figure 6: Curved coordinate system of Unibest (Deltares, 2022a).

The next step is to implement the transport rays generated in the LT model into the CL model. Unibest interpolates between the points at which the longshore sediment transport is given through the transport rays. Outside these points, the longshore transport will be extrapolated up to the boundaries of the domain. The boundary conditions of the system need to be described at the left and right ends of the system. Either the y position of the coastline or the coastline angle can be chosen to remain constant. Another option is to specify the sediment transport coming in or out of the system at this location as a constant value or as a function of time.
The transport rays will model the evolution of an undisturbed shoreline. Structures that block the sediment, such as groynes, revetments and internal boundaries can also be added to the model. Revetments may be used to prevent certain parts of the coastline from eroding, such as the port breakwater. Groynes and internal boundaries hinder longshore transport and cause sedimentation on one side and erosion on the other. To simulate the added or lost sediment in the system, sources and sinks can be used. The Maipo river will contribute to the sediment balance in the system as a source. The deep sea canyon on the other hand can be modelled as a sink, taking in sediment from the system.
The result of the model is shown in two graphs; one shows the amount of erosion and accretion along the coast during the simulation time and the other shows the longshore sediment transport (Q_s) along the coast for every timestep. Additionally, a table containing specific values for each grid point along the coast is available.

2.2.5 Limitations and assumptions of Unibest-CL+

To keep the computation time efficient, Unibest uses many assumptions and limitations. The model is best used for scenarios in which gradients in the longshore sediment transport capacity cause sedimentation or erosion of the project area for an alongshore uniform coast. It does not account for gravity-driven sediment flow.

Unibest can be used for scenarios of mid to long-term fluctuations of the coastline. For short-term fluctuations, such as changes caused by seasonal effects, Unibest is not suited as well to modelling coastlines dominated by the tide. Small changes in cross-shore sediment transport by, for example, storms can be simulated in the model by adding a source or sink in the CL-model of Unibest.

For the sediment transport, it is assumed that the model responds to local wave climate and current in such a way that the potential transport capacity equals the equilibrium transport. This assumption holds as long as the difference between the true local and local equilibrium sediment transport remains small and if the maximum horizontal grid size is larger than the relaxation effect (Deltares, 2022a).

3 Background Information and Data Gap

The first part of this chapter performs a background study on the current PGE design. Section 3.2 gives an overview of all available data used to create the models whilst Section 3.3 analyses missing data that would help formulate more reliable and effective port expansion solutions

3.1 Background study

In order to understand the project as a whole and the reasoning behind its design, it is important to first study the latest published Addendum, which the port calls its EIA. From this report, the main topics of the design that have received the most attention and discussion can be identified. This Addendum explains the changes made to the revised design of the PGE, the implications of these changes, and the reasoning behind them. The findings from the background study will serve as a foundation for establishing the network analysis and the Building with Nature alternatives for possible solutions.

Below, a list of the main aspects of the current design of the PGE and changes made from the previous design are given.

Reuse of dredging material

The new design sees the dredging material being reused within the project works instead of being dumped as done in the previous design. This was done to reduce the area of influence and impacts on the marine environment. This dredged material will be reused for the filling of the breakwater and terminals (Jaime Illanes & Asociados, 2022c).

Llolleo Lagoons (*Lagunas de Llolleo*)

The Llolleo Lagoons will not be modified or intervened in and the Ojos de Mar sector will no longer be eliminated, unlike in the previous design. Therefore, the port authority claims that there will be no loss of native fauna and no considerable impact in this area (Jaime Illanes & Asociados, 2022c). They also claim that there will be no physical or chemical alteration of the components of the lagoons, nor of the ecosystem flows (Jaime Illanes & Asociados, 2022e). In order to maintain access to these lagoons, the port will incorporate pedestrian routes, trails and observation points with adequate infrastructure for community visits (Jaime Illanes & Asociados, 2022e). These measures are shown in Figure 7.

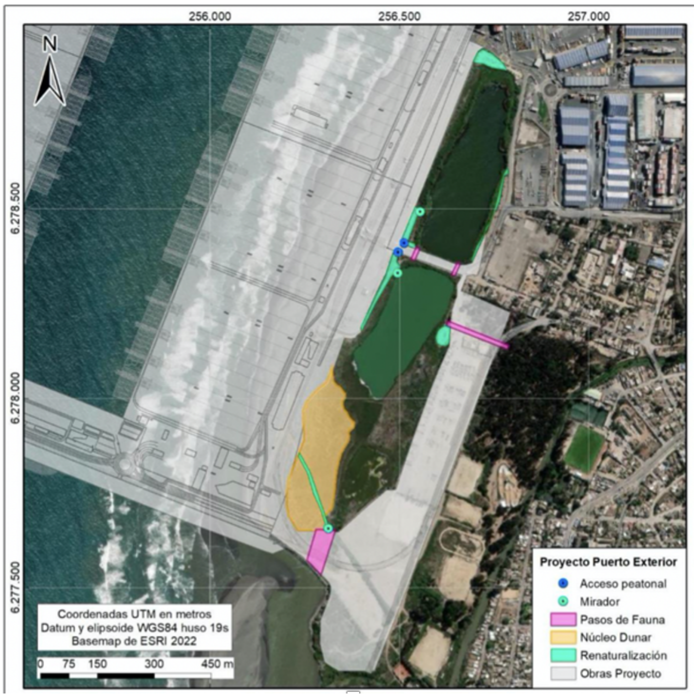


Figure 7: Measurements in Llolleo Lagoons (Jaime Illanes & Asociados, 2022d)

Llolleo Beach

The Llolleo Beach on the northern side of river Maipo will no longer be accessible by the public as a social meeting point or for recreational use. The beach area will be impacted by the port works due to the current morphology of the beach changing as the breakwater is built (Jaime Illanes & Asociados, 2022f). Furthermore, Beach Avenue will be used as a “parking lot” for the construction materials due to its proximity to the port (Jaime Illanes & Asociados, 2022g). The Llolleo Beach is highly valued by the habitants of San Antonio (Jaime Illanes & Asociados, 2022f). The occupation of Llolleo Beach by the port works can be seen in Figure 7 (the entire stretch of beach between the lagoons and the sea).

Quarries

For the construction of the breakwater, the port will use rocks obtained from two quarries: the Javer and Román quarries. The areas from which rock will be subtracted and the protection zones of the quarries are shown in Figure 8.

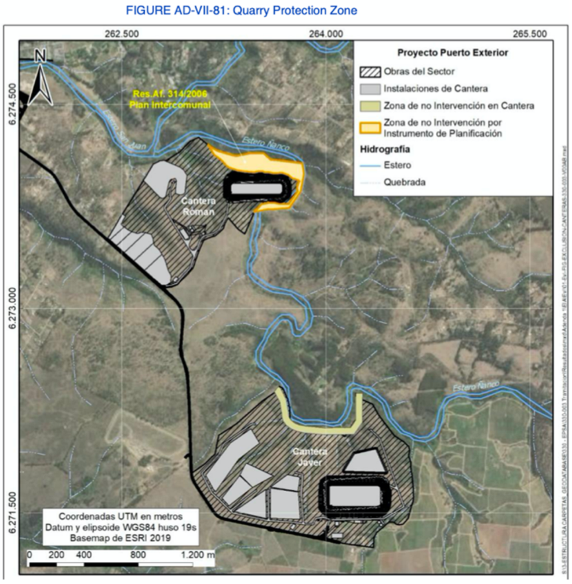


Figure 8: Quarry protection zone (Jaime Illanes & Asociados, 2022b)

In the revised design, in Chapter 2 of the Addendum, it is stated that “the amount of material to move to the port from the quarries is 379,599 m^3 from the Javer quarry and 162,685 m^3 from the Román quarry” (Jaime Illanes & Asociados, 2022c). For this, mostly trucks will be used. According to Chapter 8 of the Addendum, the maximum frequency of the vehicles will reach 155 trucks/hour/direction for the construction phase and 46 trucks/hour/direction for the operational phase (Jaime Illanes & Asociados, 2022f). There will also be a number of trains running for the same purpose, with a frequency of 9 trips/day during the construction phase. It is also stated that for the operational phase, 90% of the cargo will be moved via trucks and 10% via trains (Jaime Illanes & Asociados, 2022c).

Because of the large increase in road use for transporting rock from the quarries to the port, the port has made necessary expansions and improvements to the road and railway (Jaime Illanes & Asociados, 2022f). Such works will occur in the southern zone of the city of San Antonio (Llolleo area) for the urban sector and in San Juan for the rural sector (Jaime Illanes & Asociados, 2022f). This will inevitably lead to the resettlement of some of the population. In demographic terms, 18 dwellings are subjects to resettlement, within which there are 16 households and 36 residents. Among these 36 people, 20 reside in the urban sector and 16 in the rural sector (Jaime Illanes & Asociados, 2022f). No household or member of any household belongs to any indigenous community.

Renovation DyR Park

For the loss of Llolleo Beach, the port authority will renovate an existing park - the DyR Park. The renovation plans include the improvement and renovation of existing infrastructure, implementation of new infrastructure and improvements on the sports facilities and fields (Jaime Illanes & Asociados, 2022g). In the Addendum, however, a graphic depiction of these measures has not been given.

Maipo river

The mouth of the Maipo river will not be touched, however, some effects on the water ecosystem due to the port works are expected (Jaime Illanes & Asociados, 2022f). The Maipo river is important for two main affected parties: the natives and the fishermen. The natives' traditions and ceremonies are very closely related to nature, with Maipo being one of the most important natural areas in San Antonio for them. Areas of the Llolleo Lagoons and the banks of river Maipo are important areas for the collection of medicinal herbs and will be affected by the port or come into very close proximity to it (Jaime Illanes & Asociados, 2022e). Because of such reasons, the areas surrounding the mouth of Maipo have been declared a "nature sanctuary". This is shown in Figure 9 below. This sanctuary is located at an approximate distance of 0.26 kilometres from the closest work of the port (Jaime Illanes & Asociados, 2022a).

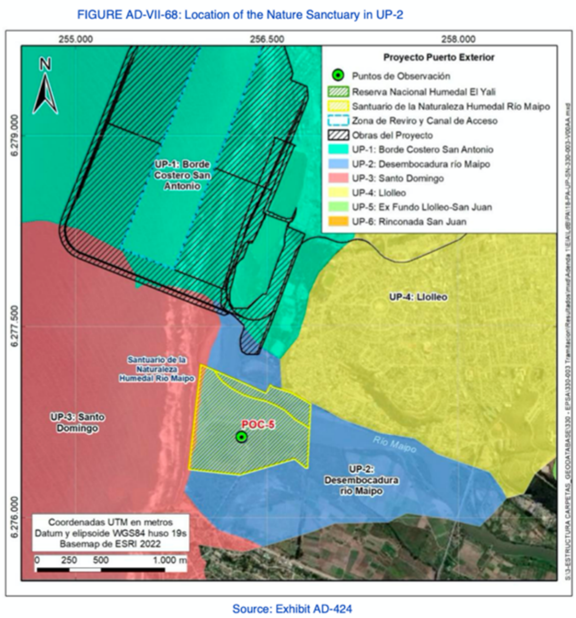


Figure 9: Location of the Nature Sanctuary of Maipo river (Jaime Illanes & Asociados, 2022b)

As for the fishermen, there is one particular group of fishermen that is closely linked to Maipo - the artisanal fishermen, who capture Chinchorro fish. Chinchorro fishing is one of the main social and economic manifestations of the fishermen and people of San Antonio (Jaime Illanes & Asociados, 2022f). Chinchorro fishing is carried out in a fishing boat, where there are four fishermen consisting of three oarsmen and a skipper, who throws the net into the sea. As such, it is done in the shallow sectors of the coastline, which is why one of the most characteristic and fitting places for Chinchorro fishing is the sector of the mouth of the Maipo river, because of its wide beaches and shallow depths (Jaime Illanes & Asociados, 2022f). The main Chinchorro fishing area is shown in Figure 10 below.

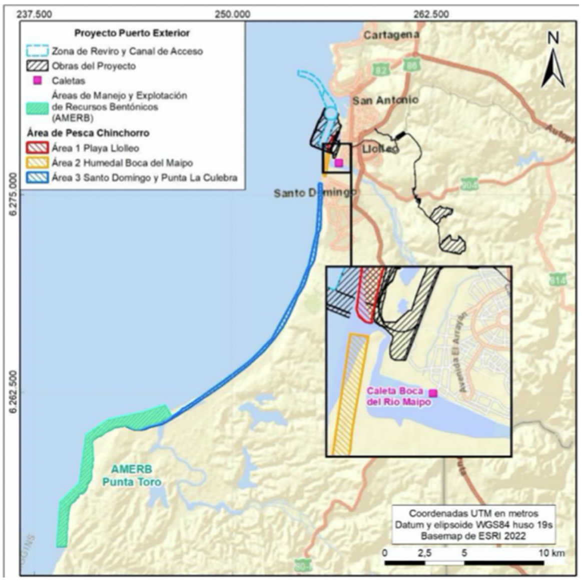


Figure 10: Main Chinchorro fishing area (Jaime Illanes & Asociados, 2022d)

Because the port anticipates an impact in Chinchorro fishing, a "Fishing Sustainability Support Program" has been developed, the details of which can be found in Jaime Illanes & Asociados (2022g). The port points out in the Addendum that they have tried reaching out to the fishermen of different coves to convey such plans and to further discuss their needs and compensations multiple times, but to no avail (Jaime Illanes & Asociados, 2022d). In the Addendum, it is claimed that the port made numerous field visits and tried reaching out via telephone calls and letters to request the participation of the community. The community has so far refused the call (Jaime Illanes & Asociados, 2022d).

3.2 Model data

In this section, the model data, which was needed to set up the hydrological and morphological models is elaborated. The historical maps used are displayed in Appendix A.1.

3.2.1 Offshore wave climate

The offshore wave climate in front of the Chilean coast can be characterized as a unidirectional swell from a direction of 226 degrees North (Beyá et al., 2016). The peak period and the mean period are 13.2 and 8.6 seconds respectively with a significant wave height of 2.30 metres, averaged. The offshore wave data used is provided by the Atlas de Oleaje de Chile (AOC) (Beyá et al., 2016), which is a wave model specialized for the coast of Chile. The data is generated using the Wavewatch III model, calibrated with satellite and buoy measurements for the period 1980 until 2015, with a sampling rate of every 3 hours. The closest node of the dataset to the project area is the Valparaíso node (33°S, 73°O), approximately 143 kilometres offshore, Figure 11. The wave roses for the significant wave height and the peak period are shown in Figure 12. Furthermore, hourly wave data from the ERA 5 model is accessible for the period 1979 - 2014 (ECMWF, 2022). The model is validated globally and its closest node to the project area is (33.5°S, 72°O), approximately 36.5 kilometres offshore. Both databases include significant wave height (H_s), peak period (T_p), peak direction (D_p) among a list of other parameters.

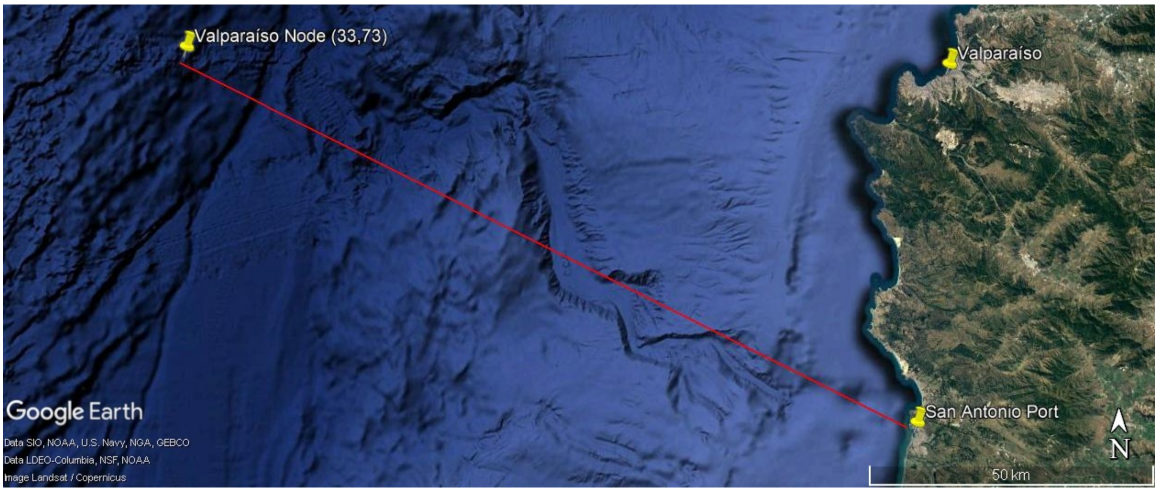
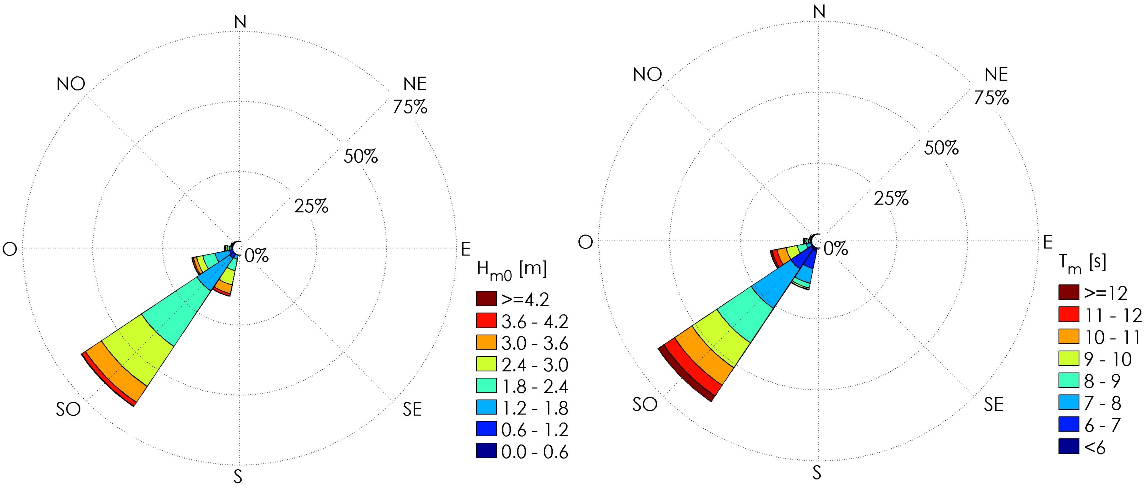


Figure 11: Location of the offshore wave climate node (Google Earth, 2022)



(a) Significant wave height wave rose (b) Peak period wave rose

Figure 12: Offshore wave climate Valparaíso node (33°Z, 73°O) (Beyá et al., 2016)

The water characteristics including density, temperature, salinity and viscosity are described in Appendix A.2.

3.2.2 Nearshore wave climate

Limited nearshore wave data is available. However, two ADCP measurements covering the period between June 10 and July 23, 2010, are found from (PRDW, 2017). The measurements are made at two locations near the Port of San Antonio as shown in Figure 13 and measure significant wave height, peak period and peak direction. The results of the measurements are shown in Figure 14.

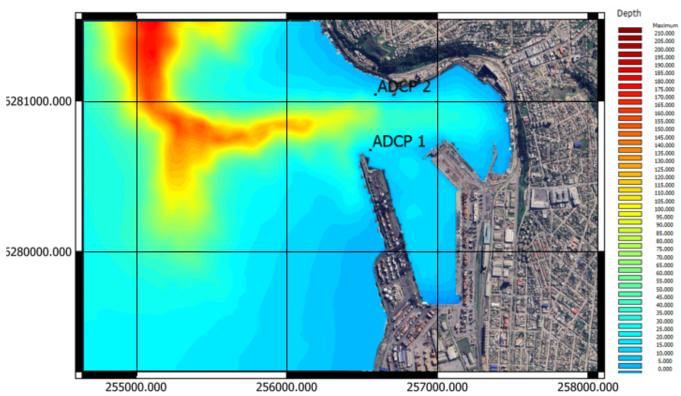


Figure 13: Locations of the two ADCPs used for model validation.

Figure 14: Nearshore significant wave height, peak period and peak direction results measured from two ADCP locations near the Port of San Antonio.

3.2.3 Wind climate

The master plan (Puerto San Antonio, 2013) mentions wind speed and direction measurements taken at the meteorological station of the Navy, Punta Panul Lighthouse (33º34'18" S, 71º37'24" W), measured during the period May 1991 until October 2000 displayed in Figure 15. The data is measured every 6 hours, measured at a height of 10 metres and averaged over 10 minutes. It is observed that the prevailing winds are from the SW quadrant (41% occurrence), followed by the NW quadrant (34% occurrence).

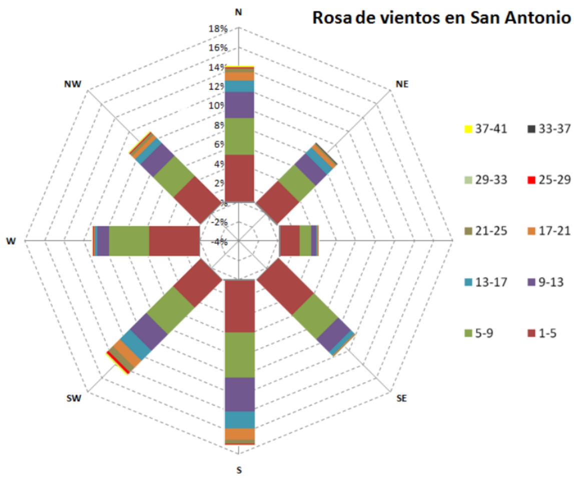


Figure 15: Wind rose for San Antonio with velocity expressed in knots (Puerto San Antonio, 2013)

3.2.4 Tides

The tide can be characterized as mixed semidiurnal with an approximate average tidal range of 1.0 metres. Measurements are available from inside the port bay (33º34'53.58"S, 71º37'05.48"W) from March 2013 until the current day with minimal interruptions. The water level variation is measured with both a pressure sensor and a radar sensor, as displayed in Figure 16.

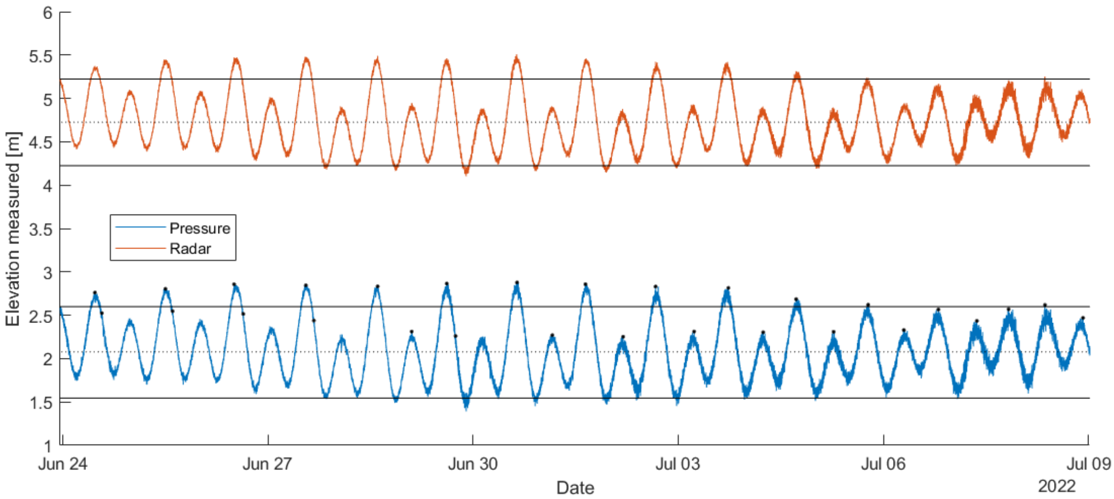


Figure 16: Arbitrary period of tidal elevation measurements (VLIZ and UNESCO, 2021)

3.2.5 Currents

The master plan (Puerto San Antonio, 2013) concludes that even in the most extreme case, marine currents are not exceeding 1.2 knots (0.6 m/s) along the navigation channel.

3.2.6 Bathymetry

The nearshore bathymetry is obtained from SHOA, an agency of the Chilean Navy managing situations dealing with hydrography and oceanography and SECOS, the Coastal Social-Ecological Millennium Institute, displayed in Figure 17. This dataset has a resolution of approximately 100 meters. Appendix A.9 describes the manual extension of this dataset such that the whole project area is covered. For the bathymetry further offshore, GEBCO bathymetry is used, as described in Appendix A.9. Distinctive is the submarine canyon stretching from far offshore into the port.

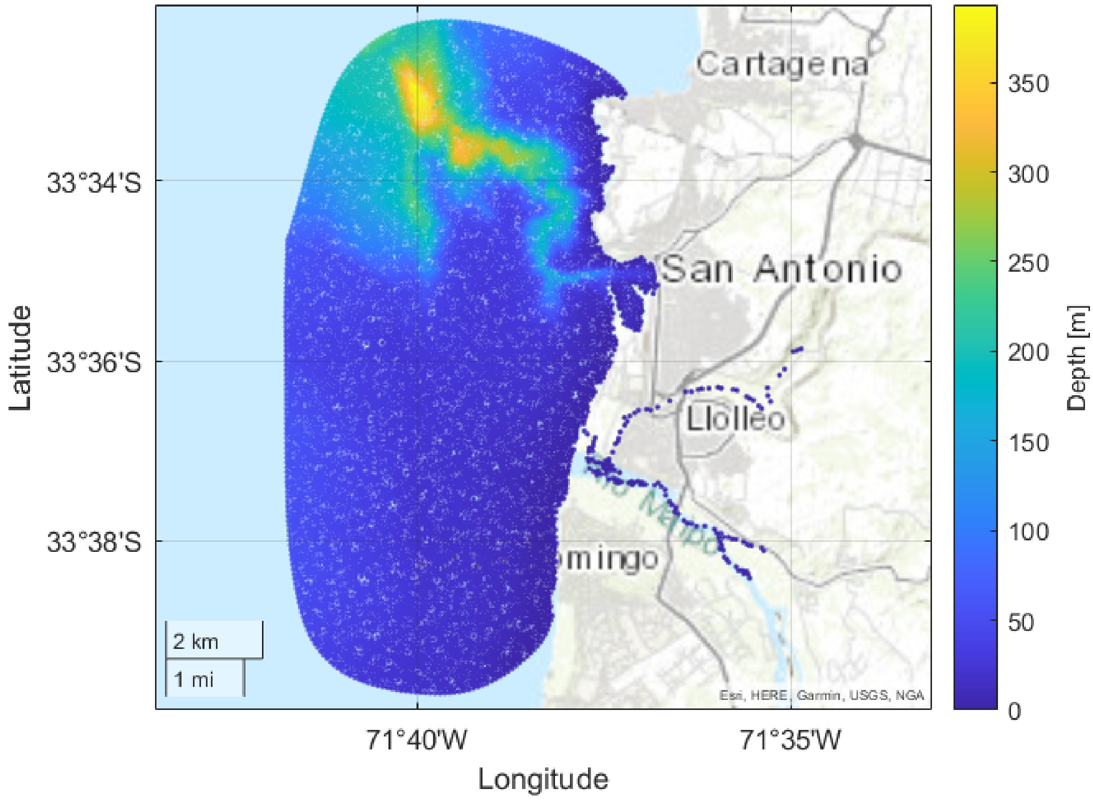


Figure 17: Nearshore bathymetry (SHOA and SECOS, n.d.)

3.2.7 River Maipo discharge

The discharge of the Maipo is characterized by a low base flow caused by the meltwater coming from the Andes Mountain range and peak discharges caused by precipitation events. Measurements gathered from CR2, (2021) give the daily average discharge of the river for the period 9/04/1939 to 31/03/1944 and 01/01/1980 to 05/06/2020 shown in Figure 18. The mean discharge observed is 127 m^3/s.

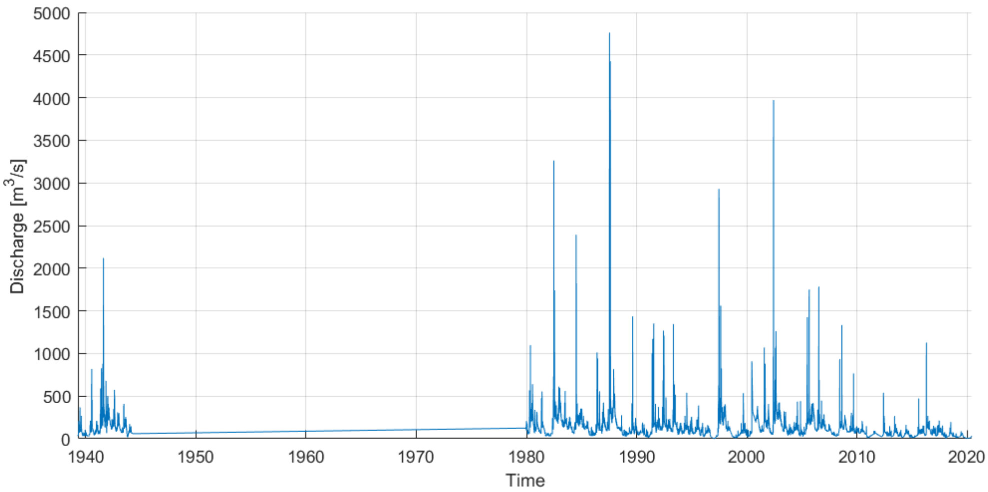


Figure 18: Discharge measurements of the Maipo river

3.2.8 Sediment characteristics sea-bed

Various research around the project area provides data on sediment characteristics. Although the sediment characteristics vary both in time and space; average values are used for the project area. Table 1 summarizes the findings.

Table 1: Sediment characteristics

Parameter	**Symbol**	**Value**	**Unit**	**Source**
Median grain diameter	D_{50}	0.24	mm	Elaborated in Appendix A.4
90th percentile grain diameter	D_{90}	0.43	mm	Elaborated in Appendix A.5
Sediment density	ρ_s	2650	kg/m^3	Elaborated in Appendix A.6
Porosity	n	0.4	-	Elaborated in Appendix A.6
Bottom roughness	k_b	0.02	m	Elaborated in Appendix A.7
Sediment's fall velocity	w_s	0.029	m/s	Elaborated in Appendix A.8

3.2.9 Seismic and tsunami risks

On February 27 2010 Chile experienced an earthquake of 8.8 on the Richter Scale (Britannica, 2010). This earthquake was the second-largest earthquake in Chilean history. The occurrence of this phenomenon is not rare. Chile is located at the border between the Nazca plate and the South America plate as seen in Figure 19. The Nazca plate diverges from the Pacific Plate in the west to the South America Plate in the east. In the east the Nazca plate will dive under the South America Plate, also called subduction. The subducting speed is approximately 61+/- 3 mm/year (Norabuena et al., 1999).

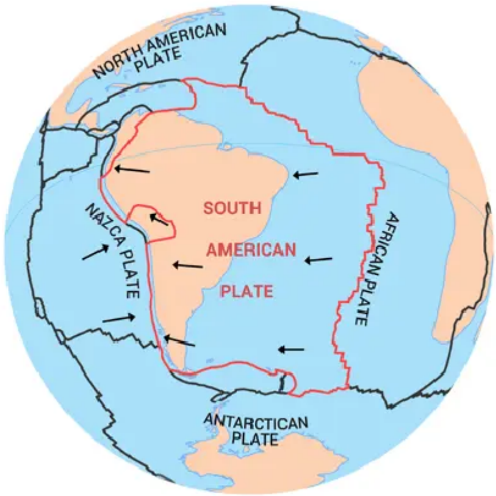


Figure 19: Nazca plate and the South America plate. (Earth How, 2022)

Because of the subduction, a deep trench was formed at the location where the Nazca plate starts to dive under the South America Plate. During the process of subduction, as one plate slides beneath another, tension builds up. When this tension becomes too great for the top plate to bear, it is released in the form of an earthquake. At the coastline, the hypo-centre is around 30 km depth because the Nazca plate is close to the surface, while deeper landwards the hypo-centre can be 200 km depth. These seismic movements in the region are a threat to the San Antonio Port development. On one hand, liquefaction is a high risk which can occur during earthquakes, because the sediment output from the river Maipo is not packed yet around the coastline. Soil liquefaction occurs when water-saturated sediments start to behave like a liquid, often during earthquakes. This transformation of unconsolidated sediments into a liquid-like substance is a common occurrence in geology. In the 1985 earthquake in Valparaiso, liquefaction was reported to have occurred (Ruiz and Madariaga, 2018; Moffat et al., 2015). On the other hand, there is a risk of tsunamis. The risk of these events occurring is high due to the very active seismic zone between 30°S and 35°S (Central Chile). The city of San Antonio is located at 33°S. In the last 50 years, a large diversity of subduction earthquakes took place (Ruiz and Madariaga, 2018). In addition, the trench-to-coast distance is short compared to other sites along the Chilean coastline. Hence, tsunami waves can reach the coastline within 15 min or less (Carvajal et al., 2017).

In the years 1575, 1647, 1730, 1822, 1906 and 1985 earthquakes occurred at the coast of Valparaiso with a magnitude of 8.0 to 8.5 on Richter, also called a mega-thrust. Therefore, the estimated probability of occurrence is one in 82 years ± 9 years (Pavez et al., 2014). The earthquake in 1730 caused the coastline to rise, and subsequent earthquakes in the region have not released the shallow slip that has accumulated since then. This means that future earthquakes in Metropolitan Chile could lead to strong tsunami excitation. Moderate shaking from a shallow earthquake could also delay evacuation efforts for the highly populated coastal region of Chile (Carvajal et al., 2017).

3.3 Data gap analysis

Available background information about the current PGE design includes no account of the direct perspective of the people impacted by the project. For example there no notes concerning previous public meetings and no interviews with the public have been made or recorded.

Additionally, not all data required for an accurate simulation of the situation is available. Due to this data gap, the modelling results are less accurate. The missing data affects the amount in which the models can be validated. An overview of the missing data is given below.

The sediment discharge is determined based on the river Maipo discharge. This is the only value available to calculate the sediment discharge. The acquired sediment outflow from the river would be more accurate by using a river depth value which correlates to a certain discharge value.

The nearshore wave data in the project area can most accurately be obtained from ADCPs measurements. However, only one month of ADCP wave data is available at two locations near the entrance to Port San Antonio. Therefore SWAN will be used to obtain the nearshore data by propagating offshore wave conditions. Due to the lack of ADCP measurements in the project area, validating the quality of the created SWAN model might be challenging.

Precise bathymetry is not available for the complete project area and certain assumptions and interpolations will be used to complete the bathymetric dataset needed. The available historical bathymetry data is obtained from old maps from the years 1870 and 1925. From 1980 onwards satellite images are available for use. This makes validating the coastline between 1925 and 1980 harder as the exact date the coastline reached equilibrium is not known. In addition, the wave climate changed slightly during the same period, which makes the validation even harder.

4 Network Analysis

In this chapter, the stakeholders involved in the project are identified and their links with each other and the project are analysed. This is done to analyse some of the challenges the project is facing during its evaluation process. Ultimately, the goal of the network analysis is to provide input for the bridging of the port and the people and most importantly, to provide the context needed for the construction and evaluation of the Building with Nature alternatives.

The analysis starts with the identification of the relevant stakeholders and an exploration of their aims and involvement (Section 4.1). After this, the political tensions, in other words, the tension between the public and the port, are described (Section 4.2). These are important for the network analysis because they provide important context which cannot be obtained from the addendum published by the port which describes the planned project works and environmental studies, as well as the perspective of the public. Based on these two sections, an issues analysis is conducted (Section 4.3). After the occurring issues and problems are identified, the narrative shifts into managing these issues and making the process better (Section 4.4). Before giving a summary of the main findings of the network analysis in Section 4.6, some relevant legislation with regard to alternative formulation is given in Section 4.5.

4.1 Stakeholder analysis

To start the network analysis, a stakeholder analysis is conducted first, the purpose of which is to find the actors of the system (in relation to this report's scope) and how they are related to or affected by the system. To begin with, the relevant actors of the system are listed below:

- **EPSA**: *Empresa Portuaria San Antonio*, is the governing public body, in essence, the port authority, in charge of the expansion project *Puerto Exterior de San Antonio*. EPSA is in charge of the preparation of the terrain during the pre-construction, the works during the building and operation phases, as well as conducting environmental surveys and assessments for all aspects affected by the port works, such as social and natural aspects.

- **Environmental NGOs**: Environmental organisations, including environmental activists who are very active and vocal about the process. They have a negative stance against the port because of the fear of drastic or considerable change to the ecosystems, especially marine ones, as well as due to the changes in nature that are bound to happen as a result of the port works, over a long time. The environment is of high importance to Chile, and increasingly more, which is why the ones advocating for it not only have a high interest in such a project, but also the power to affect it.

- **Fishermen**: The change in the environment can have an effect on the fish supply. Two types of fishermen are affected by the works: the ones that do normal fishing, who are worried about what changes their employment and income experience, and the artisanal fishermen, particularly those that fish Chinchorro, who are worried that with the changing environment, the mouth of river Maipo alongside the change of the marine ecosystem will stop such fish from being able to survive, and hence, them not being able to continue with their tradition.

- **Habitants**: People who are directly affected by the expansion project, mainly those living next to or close to the quarries and those that will have to be displaced due to the works.

- **Natives**: Indigenous communities that live in San Antonio, particularly those situated around the mouth of river Maipo. For them, nature is sacred and should ideally not be touched. Nevertheless, they realise that sometimes works that change or influence nature has to be made, albeit not ones that damage it. They are interested in historical religious sites and the river Maipo since Maipo is closely tied to their traditions and culture.

- **General public**: Citizens of San Antonio who are indirectly affected by the port expansion. The overall idea among the public is that the project will do more bad rather than good for them and the city of San Antonio. They do not think they will gain benefits from the project, be it social, economic or monetary benefits.
- **Regulatory bodies**: They check whether the expansion project works are aligned with the existing legal frameworks and laws and push EPSA to give an extensive account of all effects on the natural and social environment. They form the link between the general public and the affected people and EPSA. The main regulatory body is SEA (see below), which registers observations, remarks and complaints from the members of the public to make requests for the port to provide adequate surveys or answers. Ultimately, SEA has the power to halt or stop the project altogether if the measures and efforts done towards safeguarding nature are not satisfactory or acceptable by standards set by the law.

Regulatory bodies can be further specified to get a better understanding of which one plays what role. It must be noted that there are more regulatory bodies that check the project besides the ones listed below, but the most important ones, also when considering this report's scope and focus, have been chosen to explain further. A more in-depth dive into the regulatory bodies is done below:

- **SEA**: *Servicio de Evaluación Ambiental*, or the Environmental Assessment Service, seeks to protect citizens and natural resources and to ensure the good and ethical use of natural resources in order to contribute to the social and economic development of the country. Part of the SEA is **SEIA** (*Sistema de Evaluación de Impacto Ambiental*), or the Environmental Impact Assessment System, is a preventive environmental management instrument of the SEA. It allows SEA to determine before a project starts whether it complies with the environmental legislation in power and whether it takes into account potential significant environmental impacts. Administering SEIA is the main function of the SEA.
- **SMA**: *Superintendencia del Medio Ambiente*, or the Superintendence of the Environment, is the competent authority for controlling the Environmental Qualification Resolutions and whether the project is in accordance with the legislation and norms.
- ***Ilustre Municipalidad de San Antonio***: the municipality of San Antonio. It follows the project along and most importantly links the people to the project, by being a "bridge" connecting the two and by keeping the people updated.
- **DIRECTEMAR**: a branch of the Chilean Navy, which ensures compliance with laws and international agreements, not only for navigation, but also for preserving the aquatic environment and marine resources, and hence the supervision of activities that are carried out in the maritime sphere of its jurisdiction. Its purpose is the maritime development of the country.
- **MTT**: *Ministerio de Transportes y Telecomunicaciones*, or Ministry of Transport and Telecommunications, is the link between EPSA as a state company and the central government.

Based on this information, the stakeholders' goals, interests and obstacles can be derived. These can be found in Table 2. "Goals" refer to what the stakeholder is striving for, or in other words, the objective. "Interests" refer to what the stakeholder is aiming for at a more personal level, provided that their goals have been met. "Obstacles" are conditions that obstruct stakeholders from achieving their goals. After this, it is examined whether a stakeholder is a critical actor, and what its attitude and power are (Table 3), in order to further on construct a power-interest grid. These attributes (whether critical or not, attitude and power) are derived from the information presented in the directory of the port in SEIA's website. Some of this information is explicitly mentioned, for example, that regulatory bodies are critical actors because, without their green light, the project cannot go through. The same is for EPSA, as from the pertaining legal documents in the directory it can be seen that they are greatly supported by the central government and that they are the undertakers of the project. Other information, i.e., pertaining to the other stakeholders, is deduced from the Addendum, based on the results of its included anthropological studies and the nature of the observations made and concerns raised.

Table 2: Stakeholders' goals, interests and obstacles

Stakeholder	Goals	Interests	Obstacles
EPSA	- Build a new port with much more capacity - Minimise the environmental impact that comes with the project - Gather support from the public of San Antonio	- Have enough area for the growing container freight demand - Develop the economy of San Antonio	- Pressure and resistance from the public - Work cannot start before approval from SEIA - Transportation of rock material from quarries logistics
Environmental NGOs	- Prevent the port expansion project from damaging nature and ecosystems (irreversibly and significantly) - Protect green areas and wetlands - Secure transparency from EPSA regarding environmental impact studies	- Have green areas and wetlands protected by governmental bodies - Being considered a more powerful actor in the system	- Preventing nature areas from being touched/influenced by the port - Checking the validity findings of environmental surveys in Addendum
Fishermen	- Maintain their work and income - Have the ecosystem and fish supply unchanged	- Receive proper (monetary) compensation or a job in the new port	- Limited mobility to find other fishing areas
Habitants	- Have quarries somewhere else and not within the city of San Antonio - Have trucks transporting rocks from quarries to port not cause noise and air pollution, nor heavy congestion	- Not having their daily lives disturbed - Not having to relocate - Having their comments incorporated into the project	- Understanding if and how the new port would benefit them
Natives	- Remain in their unchanged habitat - Protect Maipo river	- Not having their daily lives disturbed - Not having to relocate	- Convincing the port about the danger they would pose to Maipo - No mobility
General public	- Have EPSA listen to their opinion and incorporate it into the project	- Gain benefits from project - Guard nature and ecosystems	- Understanding the benefits of a new port - Understanding fully the planned works and their implications
Regulatory bodies	- Convey the people's remarks to EPSA - Obtain environmental studies for all affected fields from EPSA	- Keep environmental and social aspects in check and study accordingly in the project - Form a bridge between the people and EPSA - Regulate industry and concessions	- Public reluctant to believe that they examine port's planned works critically

The information in Table 2 can be used to determine the attitude of each stakeholder, based on how their goals and interests clash or unify. The attitude of the stakeholders reflects whether or not they support the PGE project as it is (in the current situation). As for whether a stakeholder is a critical actor or not and its power, these are deduced from the available documents in the port's directory on SEIA's website, as explained above. From the available documents, it can be immediately deduced that EPSA and regulatory bodies, particularly SEA, are stakeholders with high power and hence, critical actors (for the reasons explained above). The other two critical actors are Environmental NGOs, and Fishermen, with environmental groups having more power due to the important legal implications on nature, which are decisive in the approval of the PGE. Fishermen, albeit critical since they personify one of the most important and traditional industries for San Antonio, do not have as much power, because implications on this industry, legally, do not hold as much power as for the environmental groups.

Table 3: Stakeholder involvement

Stakeholders	**Critical Actor?**	**Attitude**	**Power**
EPSA	Yes	Positive	High
Environmental NGOs	Yes	Negative	Moderate
Fishermen	Yes	Negative	Low
Habitants	No	Negative	Moderate
Natives	No	Neutral	Low
General public	No	Negative	Low
Regulatory bodies	Yes	Neutral	High

Next, a power-interest grid can be put together by using the information from Table 2 and Table 3. The power-interest grid helps to give a clear overview of the stakeholders and to visualise their power and involvement in the project. It follows the layout shown in Figure 20 and is based on the power of the stakeholders and their interests combined with their attitudes.

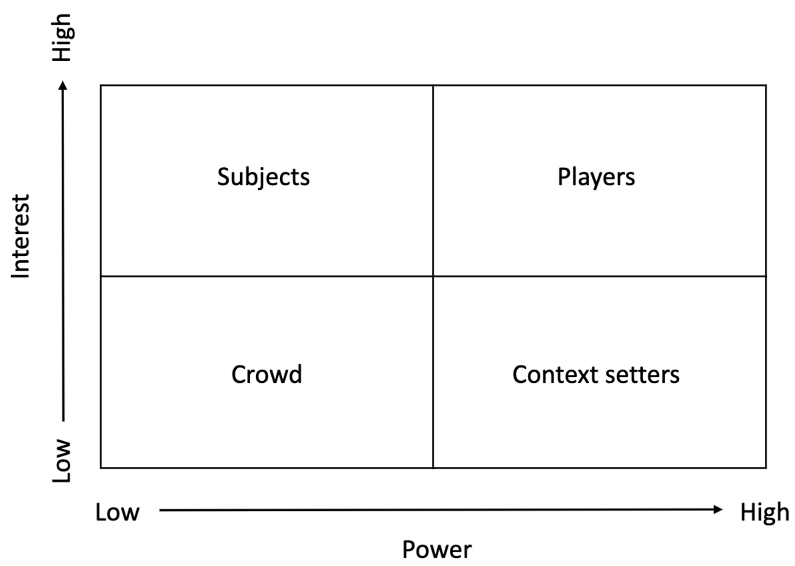


Figure 20: Layout of a power-interest grid

The following figure shows the completed power-interest grid:

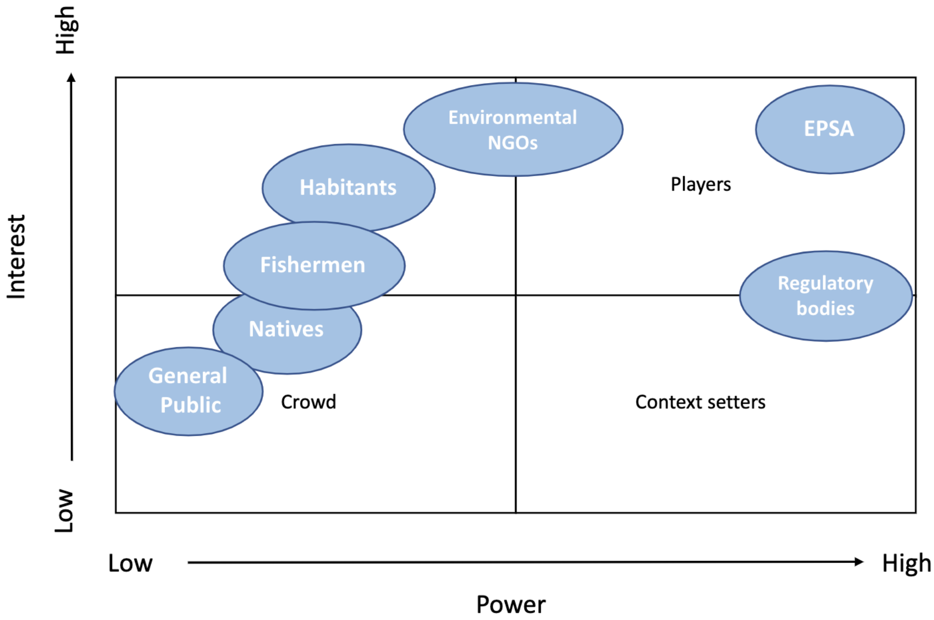


Figure 21: Power-Interest grid

Based on this grid, something that is notable is what seems to be a power imbalance. This can be seen not only in the number of stakeholders between the crowd and subject quadrants and the players and context setters ones, but also in the distribution of the power among the critical actors. The power-interest grid implies because of this distribution of power, the voices of the other stakeholders might not be heard enough, since they are not nearly as influential in the decision-making.

4.2 Political issues

As indicated in 1 and 3, there is a lot of political tension surrounding the PGE project. The tensions started with the first proposed design of the port, in the report submitted in 2020. The design was too invasive to nature and the city from the public's perspective. This marked the start of a resistance to EPSA from the public, which continues to oppose the revised design as well. In this section, the perspective of the public and its accounts are explored, in order to understand why the project is still opposed and what could be done differently in order to cease these tensions.

4.2.1 Public meetings

In order to get first-hand insight into the political issues the project is engulfed in, two public meetings were attended. The direct insight obtained from these meetings was used to verify what was presented in Table 2 above and to continue with the issue analysis in Section 4.3. The aim of these meetings was firstly for SEIA of Valparaíso (in charge of the Fifth region in which San Antonio belongs) to give a brief presentation on the environmental assessment procedure and the channels available for citizens to make observations, secondly for the owner of the project to present modifications corresponding to the latest, published Addendum of the EIA of *Puerto Exterior de San Antonio*, and lastly, for the members of the public to ask questions and for clarifications of the presented information. The details of the meetings are given in Table 4, as can be found on SEIA's website (SEIA, 2020): below, a narrative of these meetings with relevant points and findings will be given, before proceeding further on with the network analysis through an issue analysis first. It must be noted once again that the issue analysis largely depends on the findings and observations from these meetings.

Table 4: Public meetings details

Name	**Type of activity**	**Date**	**Time**	
Activity San Juan	Preparation and dialogue workshop	17-10-2022	18:00	Headquarters of Boca del Maipo Sports Club
Activity Tejas Verdes	Preparation and dialogue workshop	19-10-2022	18:00	Headquarters of the JJVV

San Juan
The following figure shows how the meeting location looked upon arrival.

Figure 22: San Juan public meeting location

The meeting started with a presentation from SEA, accompanied by slides. In this presentation, SEA explained the process of *Observación Ciudana*, or Citizen Participation Process, where the citizens have the following rights regarding an impactful project in their city:

1. Obtain information regarding the characteristics, impacts and measures taken of such a project;
2. Request a Citizen Participation Meeting if the project has a very large impact;
3. Make observations, remarks, or ask for clarity and receive answers to their questions;

It was shown in the presentation that there are four ways to participate in the EIA from SEA, those being:

1. e-SEIA
2. SEA mobile application (*SEA Móvil*)
3. By sending a letter
4. Online platform (*Plataforma electrónica*)

SEA concluded their presentation by indicating that the public had until the 22nd of November to submit their requests, doubts, comments, and complaints to SEA. The public could have the opportunity to meet with EPSA again to discuss the new remarks and answers.

According to the planning, after SEA concluded their presentation, it would be time for EPSA representatives to continue with their presentation about the revised design and plan of the port. However, this could not happen because the public immediately jumped in and started asking many questions passionately. They insisted on getting answers from the SEA and EPSA representatives. From the beginning, it could be seen how tense the situation is between the public and not only EPSA, but also SEA. The public seriously doubts whether their concerns are really considered: this is directed at both SEA and EPSA. SEA clarifies that SEA is only a public service: it records their remarks and transmits them to EPSA, but it is unable to change anything because SEA does not have the power to supervise a project of this magnitude. The public continues to be aggressive towards SEA and continues to show a lack of faith in them, by explicitly stating that "we do not trust the government". According to them, SEA "never refuses projects like this", i.e., with a mega economic impact.

By now, EPSA's presentation is underway. First, a video entailing the main changes elaborated upon in the addendum is shown, and then a presentation with the most important information for the people of San Juan. The public continues interfering with many questions during the presentation instead of after it ends. Before the discussion begins anew, EPSA states that the goal is to have the project fully completed by 2046. The first item of discussion becomes the Llolleo Lagoons (*Lagunas de Llolleo*). EPSA commits not to touch the lagoons. They say that although access to Llolleo beach will be restricted, ramps will be provided for access. They are also considering making an ecological park on the Maipo riverbank. However, the public does not agree with the statement that "the lagoons will not be touched", - although EPSA has decided not to intervene, the fact that they will be working in very close proximity to them combined with all the movement from the trucks will slowly ruin the lagoons. In turn, the public is very worried about air and marine pollution, especially air pollution due to the large number of trucks that will be moving back and forth from the quarries to the project site for several years. Furthermore, the public insists on clear explanations of what the compensation will be for the loss of the Lolleo beach. In short, the public does not want to lose the majority of the beach access they have.

SEA is then questioned if it is not necessary to make EPSA submit and present a new project since the current one has many modifications. SEA responds that they do not have the authority to demand a new project altogether, but only to organise Citizen Participation Meetings, even if the project has substantial changes. Following this, the public then proceeds to ask the EPSA representatives to explain how the revised project is not worse than the initial one, since, on paper, there are more significant impacts this time around. The hesitation of the presenting port representative to answer is met with hostility by the public, who then accused EPSA of withholding information and glossing over the impacts. Even though someone else from the representatives' team chimed in to give an answer, the public now refused to listen to their explanation.

The discussion then moves on to the quarries (Javer and Román). The public states upfront that they want the quarries somewhere else: they think "they are here [in San Juan] to just save money" because EPSA "does not really care about us". It is asked how the quarries will be re-naturalised, but there is no clear answer given by EPSA representatives. Next, the number of explosions per day and trucks during on and off-peak years is inquired, as well as the estimation on how long these will last. It must be noted that once again, there is hesitation in answering and that a concise number is not given until after some time, while still having this number changed several times within the answer. This makes the public evidently angry and accuses EPSA en masse of being dishonest. Eventually, the final answers that EPSA gave are redacted below:

- During peak times, which will be one month of year six, there will be a maximum of 155 trucks per hour per direction, from 08:00 to 20:00.
- Until the end of year six, the minimum number of trucks will be 80 per hour per direction.
- After some time after year six, the number of trucks will go down to 40 per hour per direction.
- There will be three explosions per day in Javer and two explosions per day in Román.

EPSA adds that it will be necessary to build new road sections for the passage of trucks from the San Juan quarries, although these will be small sections - the majority of the truck route makes use of the existing countryside roads, i.e. the main roads which are vital for connecting San Juan to the rest of San Antonio. Members of the audience complain that some of these roads do not even have a sidewalk - with trucks occupying them, the implication is that there will be no sufficient or safe walking space. EPSA clarifies that they are not responsible for the use and conditions of the roads used by trucks. The public is very concerned about the road capacity, as these roads are not made to handle such demand - there will be inevitable traffic jams. Furthermore, they are equally concerned about the noise and considerable air quality degradation from the sheer number of trucks passing and using such small roads. EPSA argues that their studies deem this situation feasible and within norms. They add that there is a parallel project, from the Ministry of Public Works

(MOP) which is looking into increasing road capacity in San Antonio. However, EPSA has no relation to this project (this project is only mentioned by name in Chapters 4 and 14 of the Addendum).

In continuation, the people of San Juan continue to express how insignificant they feel. They remain unclear on what will happen to them and they cannot or might not want to understand who benefits from the project. EPSA representatives try to convey some of the benefits to them, albeit vaguely, but they refuse to believe them. Firstly, the public asks, "how will [EPSA] be able to manage a mega port when [they] are not able to manage the existing port?". They add that EPSA should prepare the population for this project. Secondly, they experience much bigger problems that need more attention instead of making a new port. In the words of a public member of the audience during a charged moment:

"We don't have water. We don't have electricity. We can't leave a city worse than it was originally.[1]

While EPSA representatives understand their point, they can only say that the port expansion project does not impact access to water and electricity, thus making them not liable to exploration studies or implementation of measures concerning these aspects, as they argued.

There are also concerns about resettlement plans. When asked about these plans, the representatives were unable to answer and explain, although these plans are explained in detail in Chapter 9 of the Addendum (Jaime Illanes & Asociados, 2022g). Ergo, the resettlement plans need to be clearer and communicated more to the public.

Finally, there are concerns about how the studies are conducted and how the information they are conveying is organised. To begin with, the public is not convinced that the environmental studies are transparent, since not only are the companies or consultancy firms that conduct them hired directly by the port, but it is also difficult to find the original reports from these companies based on the references of the Addendum (in some cases, the reference is not even given). The public demands to know who is in charge of these studies and who conducts them. Tying to this, as a response to some of the questions, EPSA representatives redirect the public towards certain parts of the Addendum and its appendices. However, in order to find the information they are looking for members of the public rightfully point out that they have to open "hundreds of files", and they might still not be able to find the inquired information due to lack of good organisation of the files and/or non-matching cross-referencing. Inter alia, it is demanded of EPSA to make law application in the project clearer and to include more technical explanations in the public meeting presentations.

Tejas Verdes

The following figure shows how the meeting location looked upon arrival. This time, there was a sign indicating the purpose of the activity at the entrance.

[1] *Original quote: "No tenemos agua. No tenemos energía. No podemos dejar una ciudad peor de lo que era".*

Figure 23: Tejas Verdes public meeting location

Again, the meeting started with a presentation from SEA, but this time before showing the slides (which were the same as in the previous meeting), a video was played, which introduced what SEIA is and what SEA's competences are, alongside the rights of the public during the Citizen Participation Process (which was disclosed in the previous meeting too). There are no notable questions yet. When SEA's presentation finishes, EPSA's representative takes the stage to commence its presentation. Before doing so, this time the representatives introduce themselves and their specialisation with regard to the Addendum (the panel of experts remained the same as the one in the previous meeting). The public requested permission to raise questions immediately, however, this time an extra SEA representative intervened and asked them to answer questions later, following the order of the topics brought up during EPSA's presentation. This SEA representative was more successful at steering the discussion, and better able in imploring the port representatives to give clear and full answers to the public's questions (hence, the discussion was "smoother" in this meeting).

EPSA's presentation starts with a video showing the changes in the project, before continuing with presentation slides. In this video, it is stated that EPSA will have permanent communication channels with the public for the project. Once the video ends and the slides are put up, the exchange between the public and port representatives starts. Unrelated to the presentation, but important for setting the tone of the exchange between the two parties, a member of the public asked the EPSA presenter whether the port representatives are from San Antonio. The answer is that no, they are not from San Antonio, which leads the public to confront the EPSA representatives (and implicitly extending this to other people working for the realisation of the port) about how they as "outsiders" can understand the situation in San Antonio and the interests of its inhabitants.

The first item of discussion becomes the DyR park and the concrete plant situated next to the park and the northern lagoon. First, it was inquired how the access to DyR will be and what the plans are for the concrete plant, specifically whether it will be moved or not. The concrete plant will be moved to the beach sector, and as for the park, pedestrian access will remain and the vegetation will not be touched - EPSA will "only remake the sports facilities". The park will be renovated, with the new plan allowing vehicular access too. The public became once again enraged about the lagoons upon hearing about the plant - this and, considering that the trucks will be there in large quantities and will be parked in front of the lagoons, will in their opinion pollute the environment surrounding the lagoons, and eventually the lagoons themselves, heavily. Furthermore, the public argued that there is not enough substance for the plant at the designated location and shows great dissatisfaction by saying that "[EPSA] has not shown any respect to the lagoons".

Consequently, the public asked about how the flora and fauna will be affected by this and about the air quality studies, most specifically about where the measurement stations were located. While EPSA was able to explain satisfactorily the findings of the air quality surveys, at first, some confusion followed when they were unable to point out the locations or give a proper indication as to where they were (in the completed studies). While the public was already accusing them of lack of transparency following their hesitancy, another EPSA representative took the stage to show the air quality survey stations in Google Earth, followed by a more extensive explanation of the methodology. The same representative also made sure to specify that EPSA has not concretely surveyed the air quality for the scenario when trucks are operating fully since this is not happening at the moment (in other words, they are not mandated to do such research).

After this, the discussion continued to the rock transport from the quarries, with the public asking for the number of trucks and train access to the port. This time, a slide with a histogram of the planned number of trucks during the construction phase is shown on the screen beside the normal answer (this slide was not available during the previous meeting. EPSA indicated that there will be during peak times of the project 150 trucks per direction per hour this time, from Monday to Friday from 08:00-20:00, and for Saturday for a shorter span. Alongside the trucks, there will also be trains transporting rocks to the port - the number of the daytime and nighttime trains is shown by an accompanying slide. EPSA explains: between 07:00-22:00, there will be six loaded and six empty trains (day shift), while between 22:00-07:00, there will be three loaded and three empty trains (night shift). These are 40-car trains, approximately 300 m long. Subsequently, the public showed concern about noise levels caused by the night trains and the high number of trucks, which they argue the current infrastructure cannot bear.

The next discussion topic becomes the Llolleo beach and Chinchorro (artisanal) fishing. The people do not want to lose the main access to the beach and want the Llolleo beach to remain untouched. EPSA counters by stating that the project cannot happen without impacting the Llolleo beach. Adding to this, another part of the response that seemed to increase discontent from the public is when EPSA said that "they do not plan to build another beach as compensation". At most, some of the riverside banks can be adapted to play this role. When it comes to fishing, the public first inquires what the actual consequences will be to the sector and since the port claims to boost different sectors, what these boosts will be in reality. They add that currently they are paid nothing by the port and that they have no guarantee that the situation will not get even worse.

Lastly, the public asked how Chinchorro fishing will be protected. While EPSA's response does not explicitly indicate that the fish will disappear or become affected, they say that they have reserved other locations where Chinchorro fishing can continue. Alternatively, what this indicates to the public is that artisanal fishermen will lose their (traditional) place of work. The compensatory locations are far from where the fishermen reside (another city, Cartagena, is also mentioned, a city at about 7 km of aerial distance north of San Antonio or a 20-minute drive in normal traffic conditions from the centre of San Antonio). This answer made the present fishermen vocally angry since according to them, it is impossible to be a fisherman with a workplace so far from home; this to them means that artisanal fishing would be taken forcefully from them and that tradition will eventually be lost, as well as the source of income they depend on. They demand the port to move the project further up North and leave Maipo and Chinchorro fishing as they are, or upgrade and continue to use the current port. The port agrees that there is a need to establish dialogue, but their efforts at contacting them have been unsuccessful so far.

At this point, the public still shows distrust in EPSA's underlying motives. They do not believe that the port is doing something that will benefit the present-day population - after all the public says, they never did before. Since they do not believe them, they ask for independent experts from other countries - in the eyes of the public, they would have more credibility if the experts were not paid by the port. The essence of this can be better captured by the quote below, from a member of the audience to the port representatives:

"We need to do less and better, not more. Your bosses are the only ones who benefit from this. The port of San Antonio is of one of worst standards in continental level. We have been lied to for years. We are always sacrificed for the industries. What we need here is ministers, directors, concessionaires." [2]

Another member of the audience adds:

"We don't want this project, because it will affect all of us, and we have lived here for years. We don't want compensation, we want to live a calm life." [3]

The last additions to this before the discussion and EPSA's presentation continues is the following, by two other members of the audience:

"We live off of fishing. You don't know our sacrifices. You don't have the answers for us." [4]

"Come and look first-hand what we need, because you have no idea." [5]

The discussion resumes again with the Maipo river and water bodies in general as the topic. The public inquires what the effects will be once the inland breakwater is constructed on Maipo itself, the sediments, salinity and flora and fauna. The port gives adequate answers in turn for all aspects of the question. However, a dispute about the superficial connection of water between the ocean and lagoons and the possible affecting of the underground water follows. The port claims that the waterway connections are well-studied and that the underground water will not be affected, but fishermen refute this by saying that "[the port] has no idea how the waters actually are". One of the fishermen in the vicinity of this report's project member comments privately to their acquaintances that the current inland salt intrusion in the river is much further than the port's reports show and the recorded numbers are higher than the norm (it must be noted that this is a personal claim that could not be substantiated at that moment, nor within this project, but it did, however, influence the people around said fisherman).
A member of the public who identified themselves as an indigenous person then took the word to express the importance of Maipo to their people and how intertwined and significant it is to indigenous communities. "Maipo's river mouth has culture and history.", he said. They felt that this port was not for the people of San Antonio, but for other countries since it will be an international port. Interventions on the Maipo or effects on it thereafter would greatly affect these communities. This concluded the discussion and the meeting.

Reflection
Now that the summaries and main points/questions of both public meetings have been presented, some extra remarks can be made to help understand the links between the different stakeholders involved in and affected by the project, as well as the nuances of the disputes during the public meetings. Lastly, some areas which can be improved in terms of the organisation of such meetings or when it comes to sharing information can now be identified.

Organisation

[2] *Original quote: "Necesitamos hacer menos y mejor, no más. Sus jefes son los únicos que se benefician de esto. El puerto de San Antonio es uno de estándares mas pejores en nivel continental. Nos han mentido por años. Estamos siempre sacrificado por la industria. Necesitamos aquí ministros, directores, concesionarios."*

[3] *Original quote: "No queremos esto proyecto, porque se afecta a todos, y vivemos acquí por años. No queremos compensaciones, queremos vivir tranquilos."*

[4] *Original quote: "Vivemos de la pesca. Ustedes no saben nuestros sacrificios. Ustedes no tienen las respuestas para nosotros."*

[5] *Original quote: "Vengan a mirar lo que necesitamos, porque no tienen ningún idea."*

First, organisational aspects are discussed. To begin with, the first thing that left an impression upon arriving at the location of the first meeting is that there was no sign whatsoever that indicated that the meeting, or what kind of meeting, was being held there. For the second meeting, however, there was a clear sign at the entrance that indicated this. Secondly, during the first meeting SEA distributed handouts, however, they ran out of them quickly and before many from the audience could secure one (including this project's member). During the second meeting, there were enough handouts for the audience not only from SEA but also from EPSA. Each handout included the presentation slides of SEA and EPSA respectively (B). An important thing to note about the EPSA handout was that only the slides of the main presentation were included; some of the slides used to substantiate answers to the public's questions, such as the question about the number of trucks with the planning histogram slide, [6] were not included in the handouts. Also, this graph was only about the construction phase, even though there will be trucks transporting rock from the quarries to the port in large quantities even during the operational phase.

Preparedness

Next, the quality of the presentations, answers and discussion steering are tackled. Firstly, SEA's presentation was clear and well-prepared for the target audience for both meetings. One note needs to be made when it comes to the manner of changing the slides, even though the slides were very concise and easy to process, sometimes they were moved quite quickly. This was especially the case with the slide showcasing how to participate in the Citizen Participation progress (a quite important slide). Members of the audience might not have been able to take notes fully.

EPSA's presentation during the first meeting lacked some important information about which the target audience would most likely have questions. There were several instances where both SEA and EPSA were stuck and struggling to produce answers, with this being much more evident with EPSA. Arguably, there would be a higher chance for EPSA than SEA to be subjected to difficult-to-answer questions, because:
(1) answering questions about procedures and legal jurisdiction in practice in a particular case can be easier than answering specific, very technical questions; (2) EPSA was subjected to many more questions in number and length than SEA, meaning that the probability of uncertain answers occurring would be higher for EPSA in this case and; (3) SEA only had to explain a single procedure and the rights to the citizens for this procedure, which was rather straightforward, whereas EPSA deals with many topics, all of them extensively entailed in the Addendum and which they could have been asked on amongst other things).

As for the steering of the discussion itself, during the first meeting, the discussion was chaotic and SEA was not able to put order to it. During the second meeting, however, an extra representative from SEA was there to steer the discussion successfully. Because of this and because this SEA representative took a more objective stance by also critically pointing out to the port representatives when they answered vaguely or in a dissatisfactory manner and by insisting on them giving full information, the discussion this time was more organised.

The first meeting started considerably late, at around 18:40 instead of the planned 18:00, because the SEA representatives were late due to road blockage as a result of an accident, according to them. Nevertheless, this was sufficient to make the public already irritated and doubtful about how much of what SEA and EPSA) would be saying during this meeting would be true. This meeting ended around 22:00. On the contrary, for the second meeting, SEA representatives were there early and were waiting for enough audience to gather. This time, the meeting started at 18:15. This meeting finished at 21:30. It is noteworthy that both these meetings lasted much longer than what is indicated for the public meetings that have been held in previous years, which, according to SEA's website, would be two hours. Extending on this point, for the aforementioned meetings, no meeting

[6] *This graphic depiction of the planning was not available in the latest published version of the Addendum once this research began. It is unclear whether this will be published in a newer version of the Addendum*

notes are published: only the start and end time, duration, a photograph of the event, the number of participants and a small description of the event.

Other

Except for the remarks mentioned above, there are some last remarks that can be made for some of the topics mentioned in the meetings. Firstly, an interesting point of the first meeting was when EPSA said that "they are not responsible for the use and conditions of the roads by trucks". The phrasing of the sentence gives the feeling of an "avoidance" of responsibility. Even if the law does not explicitly hold the user of the road, be it for the construction of a mega-project or the average citizen, if the roads were to degrade because of the port works, it would be fully due to EPSA. Continuing on the same topic, one can also wonder why EPSA has no relation to the MOP project, even though they also need to build some parts of the roads in order to accommodate for the number of trucks. Lastly, based on the discussions, what the new situation would be when it comes to a beach could have been more clear, since this topic always received vague and non-conclusive answers.

In summary, the second meeting was better organised than the first one. The second meeting showed improvement in the following aspects:

- The meeting started on time, with SEA representatives waiting for enough audience to gather instead of being late.
- The port representatives introduced themselves and their specialisation this time. This made them more approachable to the public.
- There were more specialists from the port which made the panel more complete and when it comes to the questions raised, they were more prepared.
- The discussion was better organised and an order to ask questions was established. In this way, everyone had the possibility to ask their questions.
- The location was more distinguishable/recognisable.
- There were enough handouts both from SEA and EPSA this time.
- EPSA's presentation was of better quality.

That being said, there were some things that could have been better handled or more transparently communicated. These are given in the list below:

- EPSA started their presentation with a pitch video which showed the changes made in the latest published version of the Addendum and how these changes would make the situation better for the area. However, nothing was mentioned about whether this video can be found online and if that is the case, where.
- The details of both meetings could be found at least a week ahead on SEA's website, in the directory of the port expansion project. At the end of the second meeting, SEA announced that there would be another public meeting on the 24^{th} of October (the following Monday), however, the location and time details of this meeting were not added to the same page where information about all the public meetings is given, not at the day of the Tejas Verdes meeting, nor later. This might have resulted in fewer people being informed.

4.3 Issue analysis

Since there is already major resistance from different stakeholders against the PGE expansion project, different issues from different perspectives ought to be considered. For this purpose, a stakeholder-issue analysis can be done. Issue analysis and mapping can show how stakeholders might be related to other stakeholders through the issues they experience (Bryson, 2004). After issues of each stakeholder have been identified, the most common ones can be selected to create a map of the links between each stakeholder and the selected issues. Such a map can structure the problem area and can indicate areas that show potential for cooperation, or conflict (Bryson, 2004). By identifying and targeting the issues experienced by all the stakeholders involved in the process of the project evaluation, not only can possible strategies for tackling the problems be identified, but the motivation to participate in decision-making and consultation rounds can be increased (Bruijn and Heuvelhof, 2018).

As mentioned above, first, the important issues that different stakeholders have been identified, as given in Table 5. The type of participation of the stakeholder has been identified according to the five stakeholder approaches that Bryson (2004) identifies, which are:

1. *Inform*:The stakeholder will be kept informed.
2. *Consult*: The stakeholder will be kept informed; their input will be taken into account and feedback will be provided on how it influenced the decision.
3. *Involve*: Undertaker will work with this stakeholder and will make sure their concerns are considered and incorporated in the design; feedback will be provided on how their input influenced the decision-making.
4. *Collaborate*: The advice and recommendations of the stakeholder will be incorporated to the largest extent possible.
5. *Empower*: The decisions of what the stakeholder decides will be implemented.

The main issues each stakeholder has in this project context are deduced from the material provided in the Addendum and the information obtained in the public meetings. Alongside the issues and the participation type, the influence each stakeholder has on the decision-making is determined, based on the analysis done in Section 4.1. The influence attribute will help in determining the main issues the stakeholders' experience, thus making an issues mapping (as mentioned above). That is, even if an issue is not experienced by many stakeholders, if the influence of the stakeholder(s) experiencing it is high, then this issue will be taken into account, as this will give a more realistic reflection of the situation.

Table 5: Stakeholders' issues

Stakeholders	Issues	Influence	Participation
EPSA	- Insufficient existing port capacity to handle demand - Delayed start of project execution due to public unrest and environmental inquisitions - Tighter time schedule due to delays	High	Empower
Environmental NGOs	- Project works too evasive for nature - Probable contamination of the lagoons and marine environment - Significant air quality reduction - Negative effect on flora and fauna - Potential loss of public natural areas - No plans for quarry renaturalisation	High	Involve
Fishermen	- Uncertainties about the future of their jobs - Forced to continue artisanal fishing at places too far from home - Their sectors are not being boosted enough by the port - Fear of ecosystem changing and thus loss of fish (especially Chinchorro)	Low	Consult
Habitants	- Great worries about road capacity and increased travel times from trucks - Some do not want to be relocated - Increase in noise levels from quarry blasts and rock transport - Not enough compensation from port - They do not want nature touched	Medium	Consult
Natives	- River Maipo tied to their culture - they do not want Maipo to change at all	Low	Inform
General public	- Port offers no direct benefits to them - Concerns about pollution of natural areas	Low	Inform
Regulatory bodies	- There are many misunderstandings between port and people - Prolonged EIA process due to large complaints - Even if something from the plans is in a grey area, the green light has to be awarded, which can make public angrier and less prone to trusting the government	High	Collaborate

Now that the most important issues of each stakeholder have been identified, a multi-issue network can be mapped. Here, broad issues are defined and linked to the stakeholders that have them. In this way, it can be seen which stakeholders can "team up" and which are the most common (or pressing) issues. The methodology for constructing a multi-issue network also follows the one described by Bryson (2004). Stakeholders are linked to the selected issue(s) they show interest in by an arrow.

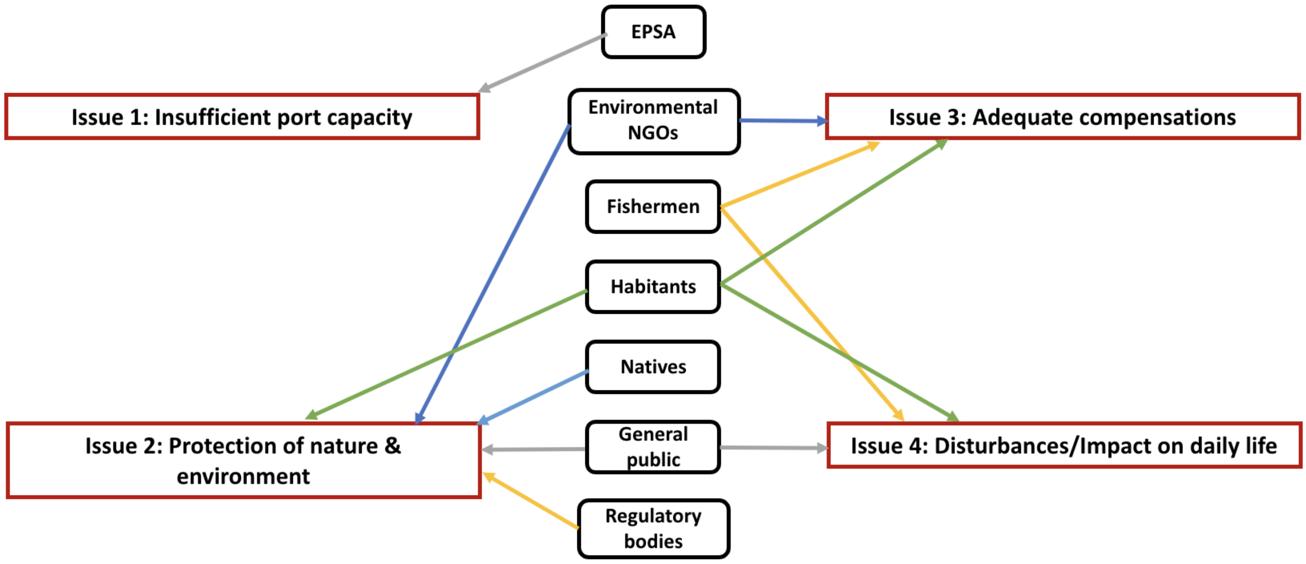


Figure 24: Multi-issue network mapping

As can be seen from Figure 24, the most pressing issue is the matter of protecting the nature and environment, followed by providing adequate compensations and reducing the impact on the citizens' life. Although the first issue, that of insufficient port capacity at present, is only a pressing issue for EPSA in this system, it must be said that this is not a small one. In fact, it is considered important and pressing enough for an expansion to be mandated by the central government. which makes the expansion of the port necessary. Even though this issue is this important, this is not reflected in Figure 24. In the issue map, it seems as if this issue is much less significant than Issue 2, which is realistically not the case, as both are very important. One could argue that this could be for two reasons:

1. EPSA is much more powerful than the rest of the stakeholders combined, which is why their issue is much more influential in the final outcome than of the rest of the stakeholders. This can be supported by the power-interest grid in Section 4.1.
2. EPSA has not communicated how pressing and relevant this issue is to the other stakeholders successfully, which is why they do not understand why this is an issue the city of San Antonio should be concerned with after all.

4.4 Managing issues and the process

Now that the main issues and problems experienced between the different parties have been established, ways with which to tackle these are explored. In this way, the design for the alternative solutions will not only satisfy the needs of the port, but it will also closely bear in mind the other stakeholders' critiques and problems with the current design.

4.4.1 Stakeholders' requirements, needs and wishes

Determining the stakeholders' requirements, needs and wishes set the path for deciding what the best way to engage them in a dialogue is and the best course of action. The requirements of the stakeholders' are formulated based on the findings from the Addendum, the public meetings, Table 2 and the issue analysis. The needs and wishes are based on the interests given in Table 2 and the issue analysis (based on how pressing and common the issue was). The results are shown in the table below (Table 6).

Table 6: Stakeholders' requirements, needs and wishes

Stakeholders	Requirements	Needs	Wishes
EPSA	- Expand port and increase port capacity - Provide compensations to people affected - Maintain effects within norms	- Receive approval with minimal changes in design - Large increased capacity in short time	- Have the public agree with the plans - Have minimal extra costs
Environmental NGOs	- Prevent the degradation of nature - Maintain effects well within norms	- Have their observations included in design - Less extensive quarry use	- Smaller port expansion - No natural area touched
Fishermen	- Guarantee of maintaining their job and income - Adequate compensations	- A boost of their sector - Better and more jobs offered by port - Keep same working location	- Have port pay them more
Habitants	- Adequate compensations - Guaranteed resettlement	- Bearable noise and air pollution levels	- Less rock transport from quarries
Natives	- Have Maipo river mouth untouched	- Minimal intervention on Maipo and Llolleo lagoons	- Their view to be more seriously considered
General public	- Receiving responses and explanations over their observations	- Receive benefits from project	- Make use of an improved existing port instead of a new, much bigger one
Regulatory bodies	- Register citizens' remarks/ questions and implore the port to give answers - Check the effect of the port's plans on the environment	- Regulate the port's plans so they fit the standards, harm nature as little as possible, and whether they incorporate the people's voice in them	- A well established dialogue between port and public, which would eventually lead to consensus

From the table, it can be seen that the alternative chosen at the end must ensure the increased port capacity (a given), and preservation of nature and no permanent damage to it. As for the evaluation process itself, it can be seen that there is miscommunication or lack of adequate compensation at the moment for all stakeholders involved, meaning that the process itself has to ameliorate. Therefore, the network analysis will continue by examining how the public can become more critically involved in the process and how the communication between EPSA and the other stakeholders can be improved.

4.4.2 Engaging stakeholders

To ensure that stakeholders are engaged in the project revision process at a considerate level, first, the project as a whole has to be studied with respect to the internal and external circumstances that surround it. For this, the analysis can be used, through which the strengths and weakness of the project can first be identified (internal factors), and then the opportunities and threats (external factors) in the environment (Dyson, 2004). The SWOT analysis can be taken a step further by performing a TOWS analysis, which is complementary to the first. After the internal and external factors are found, the TOWS matrix takes the analysis a step further by combining the various factors to formulate a new strategy towards the desired objective (Dyson, 2004). The combination of the factors can be found below, following the approach of Dyson (2004), adapted from Weihrich (1982).

Table 7: TOWS matrix for the project expansion case

	Strengths - Expansion supported by the central government - Expansion is needed due to issues with capacity - Willingness to collaborate with public from port	**Weaknesses** - Damaged relationship between port and other stakeholders - Port cannot ensure full protection from pollution of natural areas
Opportunities - Possibility to still include some of the public's points to the design - Possibility to set a standard for other similar projects in the country - Possibility to work on restoring the faith of the people on mega projects and the government	**SO** - Collaborate with public to change the design to protect their needs while still designing for the intended future capacity - Ensure benefits from new port to public and boosting of different sections via government incentives	**WO** - Make a design that touches natural areas as little as possible - Increase transparency of the design process and information presented in Addendum
Threats - Possibly harming the environment - Possibility of project not being approved by SEA	**ST** - Ask for government incentives to re-naturalise affected natural areas - Ask for government incentives for mitigation measures for protecting the nature	**WT** - Reduce the environmental impact by opting for less nature-evasive alternatives - SEA can check the design not only against norms, but also on the effect on people's daily lives

4.4.3 Steering the process

As shown in the sections above, there is great tension between the public, governmental representatives, and EPSA. Because of this, consideration should be given to strategies for steering the process, so that tensions reduce and so that eventually, a design that integrates more equally the needs and wishes of each stakeholder can be elaborated. Before delving into strategies, first, the most fitting institutional arrangement, or in other words the mode of governance, for this case is identified and explained.

Bednar and Henstra (2018) identify four modes of governance, which are shown in the table below:

Table 8: Types of modes of governance (Bednar and Henstra, 2018)

	Hierarchy	**Market**	**Network**	**Community**
Direction of Authority	top-down	circular (supply and demand)	horizontal	bottom-up
Initiating and Implementing Actors	federal, regional and local governments	government and market actors	government, private sector, and non-governmental experts	citizens, community groups, neighbourhood associations
Dominant Policy Instruments	legislation and regulation	supply and demand; government market intervention	negotiated agreements, codes of practice, voluntary programs	self-regulation, voluntary participation

Based on the information in Table 8, the mode of governance that best fits the PGE case is the network governance mode, mainly due to the fact that different kinds of stakeholders are involved (private and non-private, as well as non-governmental experts that are responsible for parts of the research for the EIA), as well as the fact that while the project is greatly interlinked with the government, there is still considerable involvement from the public at this stage. Furthermore, and most importantly, EPSA itself, the project undertaker, has shown a shift in the manner it wants to tackle this project, by showing increasingly more initiative at involving the public and less-powerful stakeholders. Lastly, considering the complexity and the tensions of this project, this mode of governance would theoretically be the most appropriate one to reduce the problems surrounding the project (Bednar and Henstra, 2018).

The core of network governance is "trust and cooperation" (Bednar and Henstra, 2018). As such, it is vital to include the public in the design process and to seriously consider the public's views for the decision-making process. There ought to be continuous communication and well-established communication channels between the parties. Furthermore, the public needs to have trust in the government and the port, not only for the information published and transmitted to them but also when it comes to receiving appropriate compensation for their losses or changes in their life.

Another characteristic of network governance is the involvement of multiple actors, each with their own point of view, goals and interests. Because there is a horizontal authority in network governance, instead of the government body being involved in the process and the project leader taking all the power, power is more "evenly" distributed amongst stakeholders. Granting more authority to other, less powerful stakeholders, provides a way to make more integrated solutions. An example of this in this particular project would be the reduction of trucks carrying rocks from the quarries since that would be beneficial for several actors. Another matter to tackle in order to make the network governance work is to make the different stakeholders willing to cooperate with each other.

Steering the process in Network Governance

Based on the characteristics of network governance and the problems experienced at hand during the process of this project, the main aspects to tackle have been identified, each of which is explained below.

Increase transparency

In order to increase trust between stakeholders from the public and EPSA and SEA, it must be made clear to the public that the results published in the Addendum are based on unbiased research and those negative implications are not being hidden, and that responsible governmental body (SEA) for evaluating the project will remain impartial until the consultation phase concludes. Furthermore, for public meetings in the future, it is important for the port representatives to be very well prepared, in order for them to not go back on their answers (which happened in several instances during the public meetings). The more concise and factual the answers that they give are, the easier it will be for the public to accept them.

Another way in which transparency can be increased, which was also demanded by the public during the public meetings, was to commission independent experts for conducting the environmental impact surveys or for fact-checking the results of such surveys. These independent experts could be from another country and work together with experts who already are familiar with the case, situation and terrain.

While on the topic of environmental impact surveys, what could add to the transparency of the information presented by the port is adding full references of such reports to the main body of the text of the Addendum, and putting these reports in more user-friendly directories. It could also be beneficial to provide the public with a summary and some explanations regarding the findings of these reports.

Better organisation of information

Easily accessible information is important for the involvement of different stakeholders and for establishing dialogue. Therefore, it is important to talk about how the information about the project is organised. The most important thing to notice is that the Addendum is a very large document consisting of many chapters, each of which reaches hundreds of pages, and this is excluding the Annexes. The last published Addendum (without Annexes), was amassed to almost 4000 pages. Since there is no summary provided for the Addendum, or at least for each chapter at the time of writing this report, it can be assumed that this may be a problem for a normal member of the general public who is interested and wants to know more about the project. The sheer amount of information may discourage a normal citizen from reading about the project and then getting more involved in the Citizen Participation Process. Even for the most avid citizens, it is difficult to find the information they are more interested in. This was substantiated during the first public meeting as well when a member of the audience complained to the port representatives that their recommendations for finding specific parts of the Annexes are not efficient, because then they (the public) would "have to open hundreds of files, and sometimes still not find it". This ties to the fact that sometimes, the annexes' names presented in the index (table of contents) do not correspond to the ones found in the online directory, nor their placements thereof. The same occurs with the referencing of the annexes via their codified name in the main body of text when sometimes these names either do not correspond to those that can be found online, or they are not published at all. To avoid confusion from the Addendum itself, it is advised to make summary reports and revise the way the information is presented.

Lastly, there is the matter of spreading awareness for the public meetings that are planned. As mentioned before, the closest planned upcoming public meeting did not have its details published on SEA's website beforehand, which may have prevented more people from finding out about it on time and attending it. There also need to be clear and attractive signs at entrances of the locations where the public meetings will happen to attract even the ones who did not know about the meeting before from the public to join them. Bigger signs could already be installed at the locations at least some days before the meetings take place. The Illustrious Municipality of San Antonio had posted about the meetings and their details on their Facebook page (screenshots of the posts can be found in B), but the port, however, had not in their profile, even though they had been quite active in the days leading up to the meetings. The port posting about such meetings as well would also help spread awareness.

Communicating value

If economical gains from the new port expansion project are made clear, as well as the ways the port intends to ameliorate different industries and the city, stakeholders from the public would also become more satisfied. As the public also clearly indicated during the public meetings, they do not see any benefits for them or the city in this project. The port must make the benefits they expect clear to the public and include this topic in their presentations during public meetings. Furthermore, the port has to clearly explain its plans about guaranteeing that the people do not lose their work occupation or that this will not be affected negatively directly as a result of the expansion project, because, at present, this still remains to be added in the Addendum as well [7]. To add to this, more stakeholders will see the project as more beneficial if plans to boost different sectors, such as fishing, or even the job market itself (by increasing the number of people employed by the port) are made and explained to the public. A way to communicate such values could be the organisation of informative workshops for the public. As for increasing the value brought to the public by the port, this could be done via agreements from the port itself or by also trying to gather subsidies from the central government that would support this. Another value/benefit that can be better

[7] *The only plan explained in the Addendum for maintaining existing or guaranteeing the work of citizens is that belonging to the people that have to be relocated for the completion of the project works, and not for the rest of the public/stakeholders*

communicated is the plans of the port to hire up to 2,020 workers when in full operation mode, the vast majority of which are expected to be from San Antonio (Jaime Illanes & Asociados, 2022a). It is unclear at the moment whether these plans are properly communicated, nor whether they can be more extensive and more adequately planned so that more people can be hired from the commune itself (based on what is said in Jaime Illanes & Asociados (2022a))

4.5 Relevant legislation

Before the alternatives are created, some possible relevant legislation that particularly indicates whether the land use that the alternatives propose and the change of the existing design are supported. The lists of the potentially relevant articles in legislation (In English and in Spanish) are given in Appendix B (Jaime Illanes & Asociados, 2020).

4.6 Synthesis of findings and conclusion

In summary, the network analysis explored the different stakeholders that are involved and affected by the planned PGE and the process of evaluation of the project. The different important attributes of the stakeholders were defined qualitatively and shown graphically in the power-interest grid (Section 4.1. Since there was a lot of information available from the port's perspective, special attention was reserved for making sure that the public's narrative was also recorded to complete the view on the situation. This was done predominantly through the public meetings that were attended. Based on these public meetings, it can be concluded that, in order to improve the quality of these meetings, there should be a better organisation of the agenda and the discussion, there is room for improvement when it comes to how prepared the EPSA and SEA are, and the meeting details should be published in time.

The main issues that concern the different stakeholders were also identified: (1) insufficient port capacity, (2) protection of nature environment, (3) adequate compensations, and (4) disturbances/impact on daily life. Based on these issues, and the internal and external factors and their combination (SWOT and TOWS), areas which can be targeted to improve the rapport between the public and the port can be identified. There are three main things to target in the process which can improve this: (1) increasing transparency, (2) better organisation of the information about the project and the Addendum, and (3) better communication of the economic and social value that the new port would bring to the people of San Antonio.