THE VALUATION OF EXTERNALITIES IN MARITIME INFRASTRUCTURE PROJECTS

Climate change and increasing environmental damage are demonstrating the urgency of transformation to a sustainable global economic model. The implementation of the sustainable development concept tends to narrow to integrating environmental, social, and economic concerns in the decision making. In economics, the definition of such concerns is an externality that represents the divergence between social and private costs. This study investigates the available sustainable asset valuation methods that can include the externalities materialised in maritime infrastructure projects and compares them based on economic, social and environmental criteria.

The need for sustainable development was initially promoted during the first United Nations (UN) conference on the Human Environment in 1972 (Smardon, 2008). The definition of sustainable development is: development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations General Assembly, 1987). The consideration of intergenerational equity is one of the essential features that separate sustainable policy from a traditional approach (Emas, 2018).

The international maritime industry is a significant stakeholder in sustainability compliance (Wang et al., 2020). Besides being a catalyst industry for economic activity and globalisation, maritime industry activities create environmental, social and economic externalities that should be accounted for to understand the actual value these projects provide to society. Furthermore, the maritime infrastructure industry is one of those industries where appropriate planning can significantly improve project sustainability. Improvements in the initial project planning related to sustainability can increase the likelihood of project acceptance by the regulatory authorities continuously working towards being more sustainable.

The improvement required to increase the quality of project assessment is ex-ante project evaluation, the inclusion of externalities that the maritime infrastructure projects create. Inclusion of externalities refers to the assurance that all related project benefits and costs are accounted for (Ding et al., 2014). Such evaluations are also known as green accounting because they include all sources of future growth (Weitzman, 2016). The project-specific externalities can be best internalised and accounted for in the project valuation by considering the three sustainability pillars: economic, social and environmental (Nastenhofer and Rammil, 2005; United Nations General Assembly, 2005).

Businesses still find it difficult and costly to include all the externalities based on the sustainability pillars due to a lack of available methodological expertise. Thus, there is a benefit to the industry from awareness about the holistic effects of infrastructure projects. There exist methodologies that include externalities that the infrastructure projects create and in such a manner estimate the actual value of the project. Use of the ex-ante evaluation of maritime infrastructure projects could lead to better management of environmental, social and economic externalities and thus improve the sustainability of the maritime industry.

This study provides a comparison of available valuation methods by answering two
questions: 1) What are the sustainable project valuation methods currently available; and 2) Which methods are the most suitable for evaluating externalities in maritime infrastructure projects? The first question is answered by employing extensive research on existing methodologies for additional information that is not publicly available. The second question is answered through a comparison study conducted using the Analytic Hierarchy Process (AHP) framework, which was introduced by Thomas Saaty (1980) as a tool for Multi-Criteria Decision Making (MCDM). Furthermore, these results will be tested using a case study of the Hondsbossche and Polderm ze (H&P) sea dyke, a maritime infrastructure project reinforced in 2015 at the Dutch seaside.

The three sustainability pillars

The economic pillar covers the effects on economic growth and the economic viability of the project. This study describes the financial perspective by indicators of taxes and wages paid, corruption effects, procurement spending, and subsidies received. The social pillar focuses on the well-being and conditions of all involved stakeholders of the specific project and their basic human needs (Brown et al., 1987). This pillar will be accounted for by effects on recreation facilities and ecotourism, heritage, aesthetics, existing infrastructure, health, safety, knowledge, and education. The most well-known pillar is the environmental pillar which stresses the economic importance of maintaining ecosystems and the diminishment of environmental pollutants. It stimulates the inclusion of externalities that appear from waste and pollution of the economic activities (Brown et al., 1987). In this study, this pillar will be based on the natural outdoor habitat biodiversity, the level of food production, freshwater production, climate regulation, water quality, coastal stability, and coastal processes energy usage, noise pollution, and fisheries.

Understanding the fundamentals of valuation methodologies

Maritime infrastructure project valuation is a complex and time-consuming task. The complexity of valuing different projects' environmental and social impacts is the main reason why valuation is one of the most challenging tasks in the project's initial stages. Nevertheless, Lara-Pulido (2018) argues that such valuations would help compensate the benefit providers, internalise environmental losses, invest in ecological infrastructure, and help to conserve natural capital. The difficulties at this level of valuation come from the estimation of environmental, economic, and social benefits that can be expressed in non-monetary values only (Carson et al., 2003; de Groot, 2006). The economic domain focuses on maximising social welfare and therefore has methods to internalise the externalities (Bohrn, 2011). These methodologies will be discussed in this section.

Monetary valuation methods

There are various monetary valuation methods that are used to estimate monetary value of goods that do not have a monetary value attached. These methods are used in the foundation of valuation methodologies which are used for the inclusion of externalities. The methods can be separated into four categories:

• Direct market valuation, based on direct monetary exchange value
• Indirect market valuation, when there are no markets for the resources that are being evaluated in financial terms
• Contingent valuation, uses survey methods that allow for creation of a missing market by determining the people's willingness to pay or accept in financial terms
• Group valuation, based on political theory and values resources from open public debates and referendum

Carson (2003) argues that excluding externalities, such as environmental, economic and social effects from decision-making processes would mean that public resources such as clean air could be harmed or used for personal benefit without incurring responsibility. The solution could be interpreted as allocation of zero value to the public resources: it is essential to recognise what monetary value the public attaches to resources to avoid the overuse of public goods (Flores, 2002). The paper by de Groot (2006) explains that valuation of benefits provided by natural and semi-natural landscapes appears from an inability to use conventional market-based economic analysis. Such inability can lead to market failures that may result in irreparable damage to environmental resources.

Therefore, there are many valuation efforts in accounting for maritime infrastructure projects' environmental, economic, and social impacts. The economic effect valuation is much more straightforward since most of the components in economic valuation are market goods and thus have a monetary value attached to them. Nonetheless, it is just as essential to have a profitable project to comply with the valuation social, environmental, and economic considerations. Therefore, proper infrastructure projects should not be pursued due to available superior alternatives.

Cost-benefit analysis

The next step of the holistic valuation is the cost-benefit analysis. A comprehensive valuation method that includes the estimated and existing monetary values in order to compare total benefits and costs of economic activity. Therefore, at the cost-benefit analysis stage all externalities should be internalised and assigned monetary values. In the case of the sustainable project valuation, cost-benefit analysis usually focuses on summing up the costs and benefits of all sustainability pillars: social, environmental, and economic. The provision of such valuation methods is advantageous in the initial stages of a maritime infrastructure project. The reasoning behind that is that maritime infrastructure projects are very capital-intensive projects and include a vast amount of regulation around them. Therefore, proper consideration of the best possible capital use and compliance with regulation would provide the most efficient resource allocation. Therefore, if projects do not align with society's use and compliance with regulation would be interpreted as attachment of zero value to the public resources: it is essential to recognise what monetary value the public attaches to resources to avoid the overuse of public goods (Flores, 2002). The paper by de Groot (2006) explains that valuation of benefits provided by natural and semi-natural landscapes appears from an inability to use conventional market-based economic analysis. Therefore, additional re-planning of the project is required to match the requirements presented by the governmental institutions.

Ecosystem Services (ES) is a commonly used approach incorporated in a cost-benefit analysis for project valuation. The ES approach provides a framework for estimating the project's total value. It divides the environmental and socio-economic externalities into four sub-groups or services that society receives from ecosystems: provisioning, regulating, cultural, and supporting services. Provisioning services are defined as basic materials retrieved from natural resources and are used by people. Regulating services provide natural resource quality regulation, such as air and water, while cultural services create opportunities for recreation, education, or other cultural benefits (Boereema et al., 2016). Finally, the supporting services focus on the primary creation of resources, such as soil formation or other ecosystem functions necessary to provide the first three ecosystem services (Boereema et al., 2016). The pruning and inclusion of services in the cost-benefit analysis are done using this structure. The valuation of ES is based on the Ecosystem Services Valuation Database (ESViC), which is the successor to the European System of Ecosystem Valuation (EEVB) and the Dutch System of Ecosystem Valuation (TEEB) that the Foundation for Sustainable Development (FSD) developed. Currently, the database holds 4,042 value records, with the majority of them being obtained in Europe and Asia (de Groot et al., 2020).

Current sustainable asset valuation methods

A review using a secondary research approach was undertaken to answer the first research question concerning finding currently available methodologies for sustainable project valuation. The criteria for the methods to be included in this study is that each method applies capitalisation in the infrastructure sector and can provide a comprehensive overview of direct impacts and at three categories of externalities: environmental, social, and economic. Thus, a methodology is only sustainable valuation if it involves all three pillars: social, environmental, and economic. If that was insufficient, the owner of the methodology was contacted to receive the accessible information. Once these requirements were met, contact was made with the methodology owner to verify the method's applicability to the maritime infrastructure industry. The methodologies that satisfied both of the requirements are described below.

Sustainable Asset Valuation (SAVI)

Sustainable Asset Valuation (SAVI) is a project assessment methodology that combines system dynamics and project finance modelling (IISD, 2020b). It is a non-profit organization that acts as an independent think tank that focuses on the creation of solutions to enhance stable climate, sustainable, and resilient economies (IISD, 2020). The impacts included in the SAVI database are environmental, social, economic, and cultural and climate risks. The three main features of the SAVI methodology are valuation, simulation, and communication.

During the valuation process, all externalities and risks are converted into monetary terms.

Once that is achieved, the SAVI incorporates system dynamics and project finance modelling (Schaep 2020). It receives the data about previously mentioned impact estimates from peer-reviewed literature, case studies, international databases and project-specific values that may be available.
from social and environmental impact assessments. The methods used to obtain impact estimates when data is not available are contingent valuation and replacement cost. ASIO has cooperated with Copernicus Climate Change Service (C3S) to acquire additional data currently implemented in the ASIO valuation methodology (ASIO, 2021c). C3S provides a database that focuses on climate and climate change impacts. Currently, the database that is implemented in ASIO methodology consists of 1354 externalities, 196 valuations of direct costs, and 11 measures of climate risks (Schägner, 2019).

Royal HaskoningDHV’s Performance Standards
The description of this methodology is based on one of the Environmental and Social Impact Assessments conducted by the Royal HaskoningDHV in addition the impact evaluation method is based on the World Bank’s 2012 Environmental and Social Performance Standards. The methodology of the Royal HaskoningDHV implements the performance standards through the following steps in the process of the impact evaluation method:

1. Identification of project actions that may have an impact.
2. Identification of sensitive areas based on the findings in step 1.
3. Identification of potential impacts generated by each project activity.
4. Recognition of standard measures that are in place to mitigate negative impacts.
5. Application of a scoring system to rank the impacts.
6. Determination of the type of each impact: direct or indirect to the affected parties.
7. Completion of impacts scoring matrix while acknowledging available standard measures that are in place to mitigate diverse effects.

Significant impacts should be subject to additional prevention actions.

HPMDo’s True Value
HPMDo’s project valuation method focuses on societal value creation and externalities internalisation in the corporate value. It connects the net values of economic, social, and environmental impacts to define true values (HPMDo, 2018). HPMDo identifies four aspects that should be considered while applying this methodology: scope, materiality, baseline and data. Scopes refers to the range of assessment since the true value methodology can be applied both on a project and company basis. Materiality defines the feature that states that they are relevant externalities should be included in the assessment. The baseline specifies the timeline for which the evaluation will be made. Lastly, data choices in the model should be of high quality and fit the given assessment. Data sources include Natural Capital Coalition for environmental externality pricing, Organisation for Economic Co-operation and Development (OECD) and Social Return on Investment (SROI) Network for social externality pricing (HPMDo, 2014). Furthermore, HPMDo bases the volume data on its internal sources such as greenhouse gas emissions, occupational health and safety data and community investment.

HPMDo’s valuation method works in a three-step manner:
1. Assessment of earnings that also includes externality valuations.
2. Implementation of risk and possible future earnings.
3. Development projects that create both corporate and societal value.

PwC’s Total Impact Measurement and Management
PwC’s Total Impact Measurement and Management (TIMM) methodology is another holistic project valuation methodology that differs from others. It includes an impact analysis separately from economic, environmental, and social pillars – using the four pillars, each composed of five indicators. This methodology identifies five main stakeholder groups: businesses directly responsible for production, businesses and other suppliers, consumers, governments, and investors. The directly involved businesses are responsible for identifying externalities and reducing and reporting them (PwC, 2013a). Additionally, they should be involved in voluntary remediation practices to reforest the damage and created externalities.

The TIMM methodology follows five steps to create a holistic impact assessment (PwC, 2013a):
1. Definition of the scope.
2. Selection of the dimensions of value.
3. Collection of existing data.
4. Sourcing of new data.
5. Analysis of the data and valuation of impacts.

Thus, TIMM estimates the impacts that can arise directly from project activity, indirectly through the choice of vendors, or induced impacts from employment and procurement spending on the economy as a whole (PwC, 2021). Furthermore, it compares possible alterations to a suggested project to find the most sustainable and efficient option (PwC, 2013b). The comparison is made through the presentation of potential trade-offs between impacts under each pillar in monetary terms.

True Price
The True Price is a methodology owned by a True Price Foundation and is developed to assess the externalities. It does so on a per-unit basis and attaches a monetary value to them (True Price Foundation, 2020). It is implemented using the following steps:
1. Provision of transparency concerning the sustainability of a product or a service.
2. Creation of voluntary remediation practices.
3. Creation of incentives to make players to become more sustainable.

This methodology identifies five main stakeholder groups: businesses directly responsible for production, businesses and other suppliers, consumers, governments, and investors. The directly involved businesses are responsible for identifying externalities and reducing and reporting them (True Price Foundation, 2013). Additionally, they should be involved in voluntary remediation practices to reforest the damage and created externalities.

EcoMetrics LLC
EcoMetrics LLC, a methodology developed by Restore The Earth, employs social return on investment (SROI) methodology to predict social, economic and environmental returns from infrastructure projects. The SROI used in EcoMetrics LLC methodology is based on principles established by Social Value International and the International Integrated Reporting Council’s Framework, IFAC Principles of Environmental and Social Sustainability, and Winrock International’s Social Value International (SVA) methodology. This methodology places the involvement of stakeholders, understanding of intended and unintended externalities, and their valuation transparency and independence in addition. In addition, this methodology places a significant emphasis on stakeholder inclusion to identify the actual values.

The SROI analysis follows the process of six steps (Hammerling et al., 2017):
1. Establishing the scope and identifying the major stakeholder groups.
2. Developing an impact map that describes the relationship between objectives, inputs, outputs, and environmental, social and economic outcomes.
3. Documenting the indicator and assignment of monetary values.
4. Establishing impact.
5. Calculating the SROI.
6. Reporting and recommendations.

Value Balancing Alliance
Value Balancing Alliance (VBA) distinguishes two main viewpoints on valuing the social and environmental impact. While stakeholders are likely to identify externalities as arising from businesses’ activities, valuation in economic terms is economically focused and seeks to understand the value from the objective and subjective well-being (IISD, 2017). The assessment is carried out by integrating social economic and environmental impacts in the VBA’s cost-benefit analysis framework to determine the value of total social impact, social and economic impact (Value Balancing Alliance, 2021a). The impacts are described at the country level to account for the common unequal distribution of externalities through regions (Value Balancing Alliance, 2021a). Lastly, the valuation of identified impacts in monetary terms is completed. Focusing on society and people’s well-being. Being well is defined based on the Organisation for Economic Co-operation and Development (OECD) framework that aims to pay attention to objective and subjective well-being outcomes on households by considering the distribution of impacts instead of the average effect only (Shinnell and Shami, 2018).

Comparison study
Since each maritime infrastructure project faces different challenges and specific externalities, the choice of an ex-ante project evaluation method should be based on the relative importance of each sustainability pillar (Laboyrie et al., 2018). In other words, the valuation method should be the best in valuing the indicators that are envolved as containing the highest risk for a specific project. The perceived high-risk externality categories are usually established using the historical knowledge for the particular project or location or by the inclusion of experts. The Multi-Criteria Decision Making (MCDM) approach was employed to compare the available assessment frameworks while considering social, economic, and environmental criteria. The MCDM is evaluated in operations research sub-discipline widely used in different fields of social science and environmental science. In this field, the MCDM is applied in various fields (Saaty, 1987). It enables the decision-makers to choose the best alternative project instead of trade-offs when a decision should be made based on multiple criteria of equal or disproportion importance.

The method applied to compare different sustainability project valuation in maritime infrastructure projects is the Analytic Hierarchies Process (AHP), created by Thomas Saaty (1980). The AHP is a one-step study that is widely used methods in Multi-Criteria Analysis (MCA) (Machiel, 2004). It is widely used in the field of social science in an assessment of social value, and thus, the method was used in a variety of project valuation methods.
The main advantages of using this method are straightforwardness, apparent simplicity, and speed. The method contributes to finding solutions (Millet and Wedley, 2002). Therefore, this can be compared using a ratio scale to the same scale. Due to this characteristic, dimensions could not be evaluated on the same scale. This method can take multidimensional decisions even if the dimensions could not be evaluated on the same scale. Consequently, the decision-maker in this study was able to separate these different dimensions.

The AHP application begins with the creation of a hierarchical structure that is separated into levels. Level 1 represents the goal or target to be achieved. Level 2 collects the main attributes on which the decision will be based as well as essential sub-criteria that are paired with corresponding attributes. Level 3 represents available alternatives by which the goal can be achieved. This structure can be seen in Figure 2. The most inclusive valuation of externalities here is defined as project valuation that can value the externalities most accurately. The externalities are project specific. Thus, the methodology that values those externalities most accurately can be called the most inclusive valuation methodology.

In this study, the goal of the decision-maker is defined as finding the most sustainable project valuation methodology. Furthermore, the decision-maker in this thesis study is a dredging company or contractor searching for the most suitable sustainable valuation methodology to apply for an upcoming infrastructure project. The decision-maker requires that the choice of an alternative is based on all sustainability pillars: social, economic and environmental. By doing so, the decision-maker can be sure to ensure the total impact of the maritime infrastructure project. However, the sustainability pillars have broad definitions that combine all possible effects of different industries on society and nature. To narrow down the spectrum of the pillars to particular indicators of common effects in maritime infrastructure projects, the sub-category was constructed specifically to the corresponding pillar.

Results of the comparison study

This section presents the results of the comparison study using the AHP methodology. Each valuation methodology is evaluated separately to find the relative strengths and weaknesses of the method. To preserve the anonymity of the relevant methodology experts, their names have not been disclosed.

The findings show that, as expected, methodologies have strengths in measuring some externalities over others. For environmental externalities, the majority of methodologies are relatively good at measuring the externalities related to air quality. This may be the case since governments widely apply regulations concerning air pollution. Water and sediment quality-related externalities are estimated more accurately by EcoMetrics LLC and SA Vi methodologies. Fish resources, mammals and ornithology category is measured significantly better by SEEA impact assessment methodology than other methodologies. Lastly, effects on habitats are best valued by the methodology of EcoMetrics LLC.

Research indicates that social externalities in the local community is best measured by the SA Vi methodology. As for tourism and recreation, the SEEA methodology is the most accurate. Concerning the archeology and historic environment, the Royal HaskoningDHV methodology is the most accurate. The externalities are project specific. Thus, the methodology that values those externalities most accurately can be called the most inclusive valuation methodology.

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project is designed under the framework of nature-based solutions, which requires innovative infrastructure designs to preserve nature in the project area. The Royal Haaksingh DHV methodology is the most accurate in measuring externalities on knowledge and innovation. However, it is important to mention that all the methodologies lack accuracy in measuring such externalities. Lastly, the H&P sea dyke project involves elements that would increase the number of leisure facilities and thus may increase the local tourism in the surrounding area. To account for this effect, the methodology of SEEA is suggested since it is the most accurate in measuring the externalities related to tourism and recreation. It was also found that H&P sea dyke project does not have significant economic externalities.

To summarise, the choice between the available methodologies to evaluate the H&P sea dyke project, trade-offs will have to be made. The EcoMetrics LLC methodology would be the best fit in regards to environmental externalities. From the perspective of social externalities, multiple methodologies could be used, specifically the Royal Haaksingh DHV the EcoMetrics LLC and SEEA methodologies. However, flood protection and defence is one of the most important externalities categories concerning the H&P sea dyke project and thus, the EcoMetrics LLC methodology is advised.

Conclusions

This study has undertaken two research questions: 1) What are the sustainable asset valuation methodologies that were found, it is noted to be concluded that there are a variety available. Furthermore, while the research found there are other methodologies were not applicable to the maritime infrastructure sector. Based on the methodologies that were found it is noted that some approach project valuation from different perspectives. For example, while the SWI methodology bases its valuation on its well-developed databases and system dynamics, and project finance models, methodologies like the Royal Haaksingh DHV methodology use local experts familiar with the applicable project area alongside their in-house knowledge and data. This makes their methodology very accurate in certain projects. The downside is that this methodology can be more costly and slower than other available methods. Furthermore, what most of the methodologies have in common is that they employ some public databases that have been created by international organisations, which may be skewed towards the more developed regions. Therefore, one could expect the currently available methodologies are less likely to estimate the projects accurately in the developing world.

The researched methodologies tend to use the guiding principles created by international organisations, such as the UN, World Bank and OECD. It is also commonly observed that the environmental pillar tends to receive the most amount of attention. Meanwhile, the social pillar is gaining an increasing amount of recognition. This could be partly due to the publicly available framework of ecosystem services, which focuses on the interconnection between the social and environmental pillars.

Concerning the research question about the comparison study, the findings of the AHP-based question were show that the different methodologies socio in different types of projects. The methodologies are different in their advantages and disadvantages, and should therefore be applied depending on the type of project and the most impactful externalities connected to them. The categories of the maritime infrastructure projects that were discussed in this study are basic recreational infrastructure, coastal and foreland defence infrastructure, offshore energy installations and fisheries infrastructure. In the case of the basic recreational infrastructure projects, the most impactful externalities concern tourism and recreation. These externalities tend to be accounted for most accurately by the SWI methodology. Based on the study results the coastal and foreland defence infrastructure projects, like the case study of the H&P sea dyke, are most accurately valued by the EcoMetrics LLC methodology since this methodology is best suited to include externalities in the flood defence category. Offshore energy installations, such as gas, oil extraction and wind farms tend to have more major impacts on the environmental pillar. To be more specific, effects on fish resources, mammals and ornithology and their habitats are some of the most impactful externalities categories to be measured in offshore energy installations, which based on the experts' opinions, are valued more precisely by the SEEA methodology. These examples show that the comparison between SWI, Royal Haaksingh DHV, EcoMetrics LLC and SEEA methodologies demonstrate that there exist various sustainable asset valuation methodologies that can be applied in maritime infrastructure project valuation. They possess various trade-offs that will require the project owner to assess the largest expected externalities to choose the most appropriate methodology.

Besides the most impactful externalities, other factors should be taken into account before setting on a methodology. The quality of data is of high importance since it will determine the quality and accuracy of the valuation. The price and time of evaluation completion are also important to consider. Therefore, further research on this topic should focus on including these variables in comparison between the methodologies to improve the accuracy of results and present a more comprehensive comparison of these methodologies.

Lastly, the comparison study revealed the advantages and disadvantages of the usage of the AHP framework. The main advantage is the ability to extract information about non-public valuation methodologies using subjective expert opinions. The comparative questions were an asset in eliciting truthful experts' responses since they created challenges for dishonest answers by following the transitivity assumption. On the other hand, it has been shown that in some cases the Saaty scale is not suitable for comparison of the ability to value the indicators, as was the case for environmental externalities methodologies for EcoMetrics LLC.  

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Summary

This article investigates the available sustainable asset valuation methods and compares them based on economic, social and environmental criteria. A review using a secondary research approach is taken to find currently available methodologies for sustainable project valuation. Eight methodologies were found to be suitable for maritime infrastructure project valuation. Using the Analytic Hierarchy Process (AHP) method, four valuation methodologies have been compared. The results of this study show that if a project has more than one significant externality, trade-offs exist between the accuracy of the valuation. The Hondsbosch and Pettemer (H&P) dyke project was used as a case study to represent a possible application of the comparison study. The findings show that for this valuation of land reclamations projects the Hondsbosch and Pettemer sea dyke, the EcoMetrics LLC methodology is the most appropriate methodology. Different maritime infrastructure projects are recommended to use various methods depending on the most impactful externalities they possess.


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