

# APPLYING THE 'BUILDING WITH NATURE' PHILOSOPHY FOR SUSTAINABLE PORT DEVELOPMENT

Opportunity study for the Port-Industrial Complex Kuala Tanjung, Indonesia



Port of  
Rotterdam

  
TU Delft



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Opportunity study for the Port-Industrial Complex  
Kuala Tanjung, Indonesia

By

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in partial fulfilment of the requirements for the degree of

**Master of Science**  
in Civil Engineering

at the Delft University of Technology,  
to be defended publicly on Thursday December 20, 2018 at 4:00 PM.

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**Cover Image:** photo (1-2-2017) of the jetty under construction which will serve the Multi-Purpose-Terminal at Kuala Tanjung. Source: <http://maritimnews.com/pembangunan-pelabuhan-kuala-tanjung-diupayakan-rampung-tepat-waktu/>.

An electronic version of this thesis is available at <http://repository.tudelft.nl/>.





# Preface

This thesis reports on my graduation work for the master program Hydraulic Engineering at the Delft University of Technology. My first acquaintance within this master program was on the topic of Building with Nature, which was an innovative course recently (2015) added to the curriculum. Two years later, during this graduation work, I followed the guest lectures of this course again to be up-to-date within this continuously innovating field of Building with Nature.

During my study, I recognised a development within the field of Hydraulic Engineering concerning the view on environmental and social impact of large infrastructural projects. Previously, projects were dominated by impact minimization, extended with mitigation and compensation measures (like the Maasvlakte 2 project). The new approach focuses on creating opportunities for the development of new nature (ecosystem services) and even using natural processes to create (part of) the design and achieve functional goals. This paradigm shift from “building in nature” to “building with nature” is needed to ensure a sustainable future, as described in the United Nations Sustainable Development Goals. I sincerely hope my contributions will form a small step towards a more sustainable approach to port development projects, which are still dominated by a drive for economic growth.

*“We need to realize that nature is not only the foundation of human well-being, but also the smartest commercial investment any business or government can make.”* (Mark Tercek, CEO of The Nature Conservancy and former investment banker, 2013)

During a three-month study project in Jakarta (Indonesia), I noted that the view on environmental sustainability of people living on the other side of the world can differ enormously. Working with people from different backgrounds and cultures is challenging but fascinating. This experience, which I just finished before starting this research at the Port of Rotterdam, helped me to understand the difficulties encountered in the Kuala Tanjung port development project.

I would like to thank the Port of Rotterdam, for allowing and facilitating me to conduct this research. It was a pleasant time with helpful colleagues and expertise in many areas. Furthermore, I would like to express my gratitude towards all members of the graduation committee for their time and support in the search for the right direction in my research. To Erik Broos, Kees Kleinhout and Robbert Wolf for their patience and time made available for the monthly progress meetings at the Port of Rotterdam. Thanks to Bregje van Wesenbeeck, who invited me to Deltares and made me aware of the (ecological) risks of coastal structures in a muddy environment. A special thanks to professor Mark van Koningsveld for his time and keeping track of the scientific path of my research. Thanks to Poonam Taneja who I could always call upon for advice and feedback. Also to David Dudok van Heel, from Royal Haskoning DHV Indonesia, who had time to discuss my ideas for the port of Kuala Tanjung, despite the time difference between the Netherlands and Indonesia. Tom Wilms from Witteveen+Bos, for his feedback and enthusiastic ideas about Building with Nature opportunities. And of course Allard Castelein, CEO of the Port of Rotterdam, for taking time to look at my research, inspiring me about investing in nature, and supporting me in promoting the Building with Nature philosophy among (future) colleagues.

*Alexander van der Hoek  
Rotterdam, December 2018*



# Abstract

The aim of the Building with Nature (BwN) design philosophy is to improve on a traditional approach for infrastructural projects by utilising natural processes to create benefits for society and nature. In a fast-changing world where climate action is becoming increasingly important, there is need for an innovative approach in large infrastructural projects where nature is not considered as an obstacle, but stimulated and used in a sustainable way. The BwN design philosophy offers the opportunity to realize this improvement.

This research first aimed to create an evaluation framework of (international) standards and goals to identify opportunities for improvement of a port masterplan and to get a better understanding of the need for sustainable port development. Included in this evaluation framework are, amongst others, the Port Vision2030, the Corporate Social Responsibility statement and the international strategy of the Port of Rotterdam (PoR). On the basis of these visions and standards, the corporate governance of the PoR was tested by conducting an informal opinion poll amongst twenty colleagues at the PoR (International, Environmental Management and Port Development).

A practical example of a traditional port development project that can be improved by applying BwN is the Kuala Tanjung (KT) Port-Industrial complex at Sumatra, in Indonesia. This port development project is still in its initiation phase where a first master plan is proposed. Since the goal of the Indonesian government is to build a world-class port, international and sustainable standards apply. This project was used as a case to identify opportunities to improve a traditional master plan by applying a BwN approach. The evaluation framework was applied to the current master plan of KT to check whether this project meets the requirements for international port development, in particular from a nature/social point of view. It is concluded that the current design mainly focuses on the functional requirements of the port, proposing mitigation and compensation measures against the negative social and environmental impact of the port development. The BwN philosophy, on the other hand, prescribes a thorough understanding of the natural system emphasizing on the positive effects of the project for stakeholders and nature, to create a win-win solution.

After applying the general evaluation framework, it became clear what aspects in the current master plan should be improved. A literature study of applied BwN solutions resulted in an onshore and offshore alternative for the port development including several BwN solutions. Together with experts involved in the KT project, it is concluded that the onshore alternative is more realistic (from a functional point of view), while still offering opportunities for applying the BwN philosophy. In the current natural system of KT the mangroves offer various important ecosystem services. In addition, it is concluded that the breakwaters proposed by the current master plan form a large part of the CAPEX. Consequently, a solution is proposed where mangroves are integrated in the design to attenuate waves and enhance nature at the same time.

To test whether this BwN solution is realistic, a preliminary feasibility study has been executed. The results of a mangrove coastal protection program at Demak (Java, Indonesia) and various scientific articles (Ecoshape BwN Guidelines, 2018) about rehabilitation programs for mangroves have been used to set up a general checklist with habitat requirements for mangroves. These requirements were compared with the local conditions at KT and recommendations for creating these conditions at the breakwater location were given. According to the checklist, the site at KT appeared to be suitable for mangrove establishment. This resulted in preliminary mangrove breakwater designs for various depths. In addition, the effect of the BwN solution on the phasing of the adapted master plan was determined, rough cost estimates were made and the implementation risks were identified. According to these conditions, the mangrove-based breakwater appeared to be technically feasible for the first 2000 m of the shallow part of the south-eastern breakwater at KT. Finally, the evaluation framework was applied again to check if the current master plan of KT has been improved (read: less dilemmas occurring from deviating standards in Indonesia) and a general advice is given on the applicability of the selected BwN solution to other ports in Indonesia and (sub)tropical zones of the Asia Pacific region.

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# 1 Introduction

In this chapter, the subject of the thesis is introduced and the relevance of the study is addressed. The background and problem description explain why the Port of Kuala Tanjung (PoKT) is used to explore the opportunities for applying the Building with Nature (BwN) philosophy. Subsequently, the objective of the study and the research questions to reach this objective are described. Finally, the scope and research methodology will be defined and related to the report outline.

## 1.1. Background

In general, port developments have a large permanent impact on the project area and the surrounding region. A traditional approach of developing a port is to make a design based on the functional requirements and afterwards assess the social and environmental impact of the design. Often mitigation and compensation measures are proposed to minimize this impact and to satisfy stakeholders. In this process the decision-making is primarily driven by functional requirements and economic growth.

An example of such a large port project with major impact on the surroundings is the development of the PoKT in Indonesia which has a high potential to stimulate local and national economy. Indonesia is already South East Asia's largest economy and is expected to be the 4<sup>th</sup> biggest economy in the world in 2050<sup>1</sup>. Indonesia consists of 17.000 islands and therefore requires efficient ports and industrial development on a large scale. Kuala Tanjung, situated in North Sumatra, is one place to make this happen (Figure 1). In December 2017 a plan was presented for the extension of the PoKT, which would become the country's largest international hub once finished. Port of Rotterdam (PoR) together with the local port authority Pelindo 1 worked together in a joint venture to realise this project. The dense shipping traffic of Malacca Strait and the populous hinterland could make this project attractive for international investors. In the long term, the port could serve as a transshipment port generating even more cargo flow. (PoR, 2018)



Figure 1 Location Kuala Tanjung at Sumatra (PoR, 2018)

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<sup>1</sup> According to PwC: 'The World in 2050' (PwC, 2017)

## 1.2. Problem description

Because of political issues the PoKT project has been put on hold since December 2017. The business plan of the current master plan still has a negative NPV and therefore asks for financial support of the Indonesian government. This is, amongst others, the result of the extensive capital investments that are needed for the basic infrastructure. In addition, the current master plan does not yet meet the international standards and the vision of the PoR. Some main aspects within the master plan that should be improved are a river diversion, resettlement of a fisherman village and the cutting of mangrove forests. Figure 2 shows an overview of the PoKT as described in the current master plan, made in co-operation with Royal HaskoningDHV (Dutch consulting engineering firm).



Figure 2 Planned final phase of PoKT (PoR, 2018)

In addition to the PoKT, 23 other port developments have been announced by the Indonesian government (President Joko Widodo – APEC Summit, 2014). Five ports are selected as deep sea international ‘port hubs’, where the PoKT has the highest priority status. Since PoR is a potential investor for several of these international port development projects, the port development needs to be improved in a more nature friendly way and according to international standards. The first challenge in solving this problem is to identify all requirements for developing a world-class port in a country where, in principle, other values and standards apply. According to PoR (PoR Indonesia, 2017):

*“International standards need to be applied during the Environmental and Social Impact Assessment (ESIA) process to resolve the environmental and social issues. Until now international standards are not applied and a structured and transparent dialogue with residents has not started yet. Pelindo 1 and PoR have decided to invite an international review, but current practice continues to deviate from international standards. Well organised environmental and social management is needed to gain trust of the world-class companies, international lenders and of course to avoid losing support from residents.”*

### 1.3. Objective and research questions

The current master plan of the PoKT can be improved by creating value for nature and society while including local and (inter)national stakeholders. Also, the port development needs to meet the applicable international standards and given functional requirements. This research aims to first create an evaluation framework of (international) standards and goals to identify opportunities for improvement of a port masterplan. A recent design philosophy that offers the opportunity to realize this improvement by developing a port in harmony with nature is the Building with Nature (BwN) philosophy. Hence, this (opportunity) study aims to develop an alternative for the PoKT which fits within the BwN philosophy. A general checklist is set up to examine under which conditions the proposed BwN solution can be applied for sustainable port development in Indonesia.

These objectives are translated into the main research question:

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**How can opportunities for sustainable port development be identified and the Building with Nature philosophy be applied to ports in Indonesia?**

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The following sub-questions will help to answer this main question:

- 1) Which set of standards and goals apply to international port projects of the PoR and how can these standards and goals in relation to sustainable development be incorporated in an evaluation framework?**
- 2) Does the current master plan of Kuala Tanjung meet the vision of the PoR, the international standards and the Building with Nature philosophy and guidelines?**
- 3) How can the current master plan of Kuala Tanjung be improved by applying the Building with Nature design philosophy?**
- 4) Which considerations are required in the current master plan in order to implement the proposed Building with Nature solution and what are the implementation risks?**
- 5) Under which conditions will this Building with Nature solution be applicable to other ports in Indonesia?**

### 1.4. Research scope and methodology

The focus of this research is on the port development of the PoKT. If the BwN solution turns out to be applicable in a broader context (thus not limited to the PoKT), the scope may be enlarged. The proposed BwN design for the PoKT, will be a preliminary design like the proposed design in the current master plan. In this research the proposed BwN solution creates a 'project effect' (e.g. long-term new bird island), and not a 'process effect' (e.g. limit turbidity during dredging). As the PoKT project has been put on hold, there are enough degrees of freedom at the moment, to create out-of-the-box BwN solutions.

The industries that may be involved in the port complex, like a coal-fired power plant and palm oil refineries are not part of the scope of this research. Moreover, the focus of this research does not lie on CO<sub>2</sub> footprint reduction which is a frequently made misconception of the BwN philosophy. In the current master plan, some decisions are made because of political strategic considerations. This research is not limited by such political strategic considerations.

The research methodology is divided in the following steps and methods:

Firstly, a desk study is carried out of the PoKT project, the vision of the PoR, the international standards and a literature study into the BwN philosophy and guidelines and applied BwN solutions around the world.

Secondly, the applicable standards are identified by interviewing experts on port development and comparing this with the available literature. This results in a new evaluation framework for sustainable international port development. This framework is accepted to be fully representative if standards (on the domain of People, Planet & Profit) start to repeat themselves. In the ideal situation, also called “Soll” in a Gap-analysis, the port development project satisfies all standards. In Figure 3 (page 6) this step is shown in yellow.

Thirdly, the impact of the current master plan of the PoKT is determined by describing the port system and surroundings (red part in Figure 3). A desk study into PoKT related documents results in a description of the current status of the port development. This part is called “Ist” in a Gap-analysis (red in Figure 3).

Fourthly, by applying the BwN design philosophy and guidelines followed by a brainstorm session with the supervisors (PoR) of this research, new port lay-outs for the PoKT are created (filling the “Gap” in the Gap-analysis) and presented in the form of conceptual sketches: multi-objective designs at a conceptual level. The inspiration for this brainstorm session included a literature study into applied BwN solutions around the world. By consulting experts (among whom supervisors of this research) one alternative is chosen to elaborate upon (green in Figure 3).

Finally, a more detailed literature study into the proposed BwN solution is carried out resulting in a general checklist of necessary conditions. This research is concluded with a feasibility study and a preliminary design for the PoKT (purple in Figure 3).

## 1.5. Report outline

After the introduction, Chapter 2 (yellow in Figure 3) will describe the applicable standards and goals for sustainable port development resulting in the above-mentioned evaluation framework. This chapter addresses the first sub-question about which standards apply.

In Chapter 3 (red) the current master plan is evaluated to identify opportunities for improvement. Based on the technical documents of the current master plan the main port system (PoKT) is introduced and the stakeholders are analysed. After this, the status and key requirements of the port development are given. Given the potential impact of the current plan, the second sub-question will be answered, whether the current master plan meets the applicable standards.

Subsequently, Chapter 4 (green) starts exploring the BwN opportunities for the PoKT project. Firstly, the project is placed within the BwN design process determining the degrees of freedom and fixed design choices. Secondly, the physical and ecological system are analysed resulting in relevant ecosystem services provided by the system. This chapter follows the BwN Guidelines. This results in new alternatives answering the third sub-question, how the current master plan can be improved.

Chapter 5 (purple) elaborates on one alternative and determines the feasibility of the BwN solution. After a literature study about the necessary conditions for the BwN solution a preliminary design will be made with rough order-of-magnitude cost estimates. After this, the last two sub-questions will be answered about the required adaptations in the current master plan and a general advice will be given about the feasibility of the BwN solution. At the end of Chapter 5, the evaluation framework of Chapter 2 is applied again.

In Chapter 6, the discussion, recommendations (prerequisites to success) for the PoKT project will be given and an overall conclusion will be drawn answering the main research question.

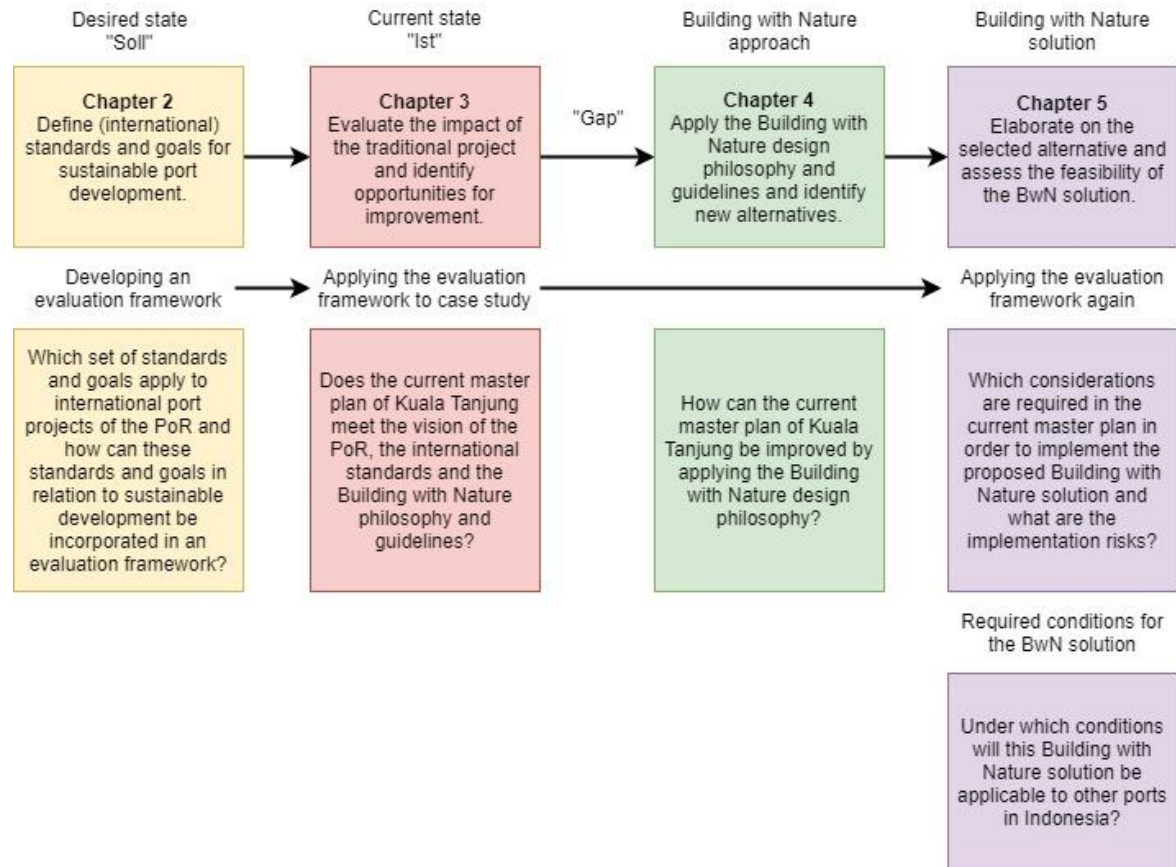


Figure 3 Research steps: Chapter 2 (yellow), Chapter 3 (red), Chapter 4 (green) and Chapter 5 (purple)





# 2 Standards for international port projects and sustainable development

The ambition to build a world-class port implies that world-class standards in contracts and rules & regulations must be applied. In addition, the PoR has its own mission and vision and Corporate Social Responsibility statement (CSR-statement) for the port activities in Rotterdam but also for the involvement in port projects elsewhere in the world. To determine the corporate governance of the PoR an opinion poll concerning the vision of the PoR on international projects is conducted. Sustainability and preventing global warming are increasingly important and therefore asks for a global approach. The PoR supports the United Nations Sustainable Development Goals (UN-SDG) and is therefore already exploring the philosophy of BwN. In this chapter the international standards and BwN guidelines will be explained and relevant requirements will be incorporated in an evaluation framework (see [Chapter 6](#)). These standards and the vision of the PoR will clarify the different views on the requirements of participating in large international port projects.

Standards	Abbreviation	Source
<ul style="list-style-type: none"> <li>Port Vision 2030 (2011) and annual progress reports on this vision</li> </ul>	Port Vision 2030	(Port Vision 2030, 2011)
<ul style="list-style-type: none"> <li>Annual Report of the Port of Rotterdam including the CSR-statement, mission, vision and strategy (2017)</li> </ul>	Annual Report PoR (2017)	(PoR Annual report, 2018)
<ul style="list-style-type: none"> <li>International strategy of Port of Rotterdam International (2018)</li> </ul>	Strategy PoRint (2018)	(PoR International, 2018)
<ul style="list-style-type: none"> <li>Expert opinion regarding international businesses of the Port of Rotterdam (2018)</li> </ul>	Expert opinion PoR (2018)	Appendix F
<ul style="list-style-type: none"> <li>Dutch ministry of Foreign Affairs: OESO Guidelines for multinational enterprises (2011)</li> </ul>	OECD Guidelines for Multinationals (2011)	(OECD, 2011)
<ul style="list-style-type: none"> <li>IFC's Sustainability Framework (Environmental and Social Sustainability Policy Statement 2012) including the IFC Performance Standards</li> </ul>	IFC or IFC-PS 1,2,... (2012)	(World Bank Group, 2012)
<ul style="list-style-type: none"> <li>IFC's Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals (2017)</li> </ul>	IFC-EHS (2017)	(World Bank Group, 2017)
<ul style="list-style-type: none"> <li>Convention on Biological Diversity describing the Strategic Plan for Biodiversity 2011-2020 (2010)</li> </ul>	Convention on Biological Diversity (2010)	(Convention on Biological Diversity, 2010)
<ul style="list-style-type: none"> <li>UNESCO Convention concerning the protection of the world cultural and natural heritage (1972)</li> </ul>	UNESCO (1972)	(UNESCO, 2018)
<ul style="list-style-type: none"> <li>United Nations Global Compact guide to Corporate Sustainability (2015)</li> </ul>	UN Global Compact (2015)	(United Nations, 2015b)
<ul style="list-style-type: none"> <li>United Nations Sustainable Development Goals (2015)</li> </ul>	UN-SDG 1,2,...(2015)	(United Nations, 2015a)
<ul style="list-style-type: none"> <li>Ecoshape Building with Nature Guidelines (2018)</li> </ul>	BwN Guidelines (2018)	(Ecoshape BwN Guidelines, 2018)

## 2.1. Vision of PoR

The PoR Authority is an autonomous company with two shareholders, the municipality of Rotterdam and the Dutch state, established to develop the port of Rotterdam.

### **Mission**

"The Port of Rotterdam Authority creates economic and social value by working with customers and stakeholders to achieve sustainable growth in the world-class port."

As can be read in the mission above, the PoR not only wants to create economic value but also takes social value into account. Sustainable growth plays a key role in creating these values.

### **Vision**

"We continually improve the port of Rotterdam to make it the safest, most efficient and most sustainable port in the world. We create value for our customers by developing logistics chains, networks and clusters, in both Europe and growth markets worldwide. As an enterprising port developer, the Port Authority is the partner for world-class clients. In this way, we are also strengthening the competitive position of the Netherlands."

The PoR has a sharp vision for the port and industrial development in Rotterdam stated in the "Port Vision 2030". In this Port Vision efficiency and sustainability play a key role contributing to the welfare of the region, the Netherlands and Europe. The vision of the PoR states that in 2030 the third Maasvlakte (extra extension) is not necessary, the port will be cleaner, more silent and safer. Also, congestions on the A15 (highway to the port) must be reduced while employment opportunities are stimulated.

The PoR aims for more use of renewable energy and bio-based chemicals. To reduce the CO<sub>2</sub> emission, sustainable construction is introduced, and CO<sub>2</sub> must be captured in the future. The Global Hub and Europe's Industrial Cluster are the pillars on which this Port Vision 2030 is based. Since 2012 an update about the status of the Vision 2030 is published in the form of annual progress reports. (Port Vision 2030, 2011)

Next to Rotterdam, PoR is also internationally active in 'SOHAR Port and Freezone', a fast-growing port in the Middle East, Porto Central, a greenfield development in Brazil, and probably shortly the greenfield development of the PoKT in Indonesia. Together with these ports a World Port Network is formed. Within this network, world-class standards in contracts and rules & regulations are applied consistently. Until 2017 PoR focussed mainly on international port developments as an investor or consultant in 'greenfield'-developments in emerging economies, but in 2017 PoR also focussed on so called 'brownfield'-developments (on land which is vacant and usually industrial in nature).

Recently, on the 30<sup>th</sup> august 2018 PoR decided to participate in the port of Pecém, a fast-growing port in Northeast (NE) Brazil. The participation involved an investment of 75 million euros, and in addition to holding 30% of the shares, the PoR will have joint control of strategic decisions and positions at the executive board, supervisory board and management level. Before this participation, the PoR has already been consulting for the port development of Pecém for several years.

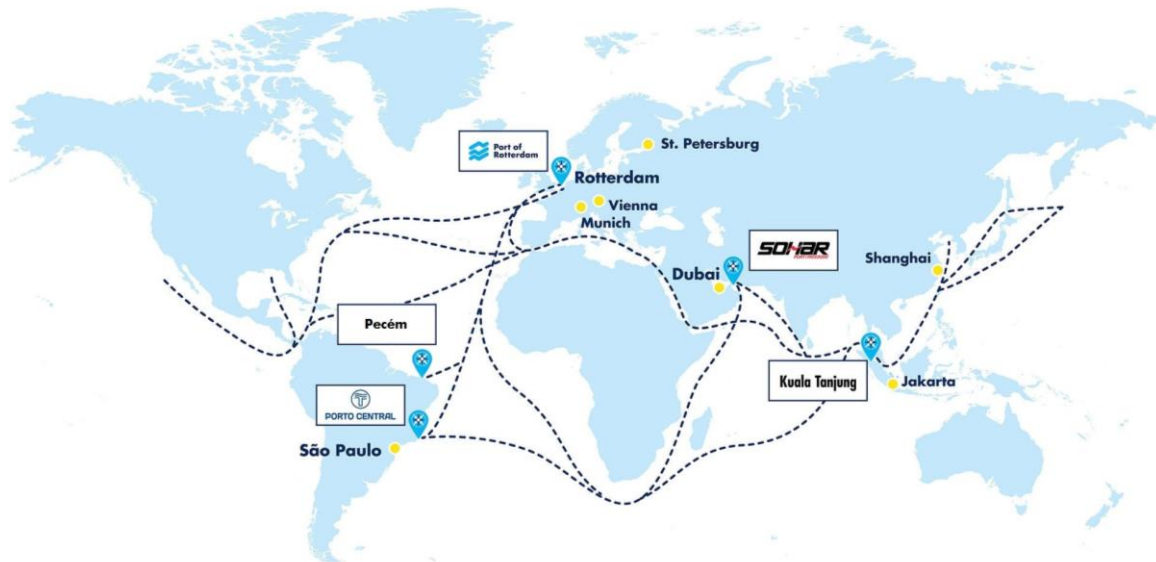


Figure 4 World Port Network - Port of Rotterdam International (www.portofrotterdam.com, Pecém added)

The PoR has a Corporate Social Responsibility (CSR) statement which shows what PoR stands for. PoR takes responsibility for their impact on society. The CSR is more than just obeying to the law and acting legally right. The CSR of the PoR states:

*"We work to build a vital, future-proof port where economic growth and improving the living environment go hand in hand. We conduct our operations in a socially responsible way, with respect for people and the environment. Our efforts are focused on the port and on our own organisation. Safe & Healthy Environment, Climate & Energy and People & Work are our key themes in this respect."*

#### **Safe & Healthy Environment**

*Safety is a top priority in our port. In addition, we constantly work to provide a healthy and attractive living environment.*

#### **Climate & Energy**

*We are dedicated to combatting climate change. The Port of Rotterdam is the place where the energy transition is taking shape.*

#### **People & Work**

*We are committed to socially responsible employment.*

*How does the PoR reach these goals?*

#### **Moral Compass**

*We act with integrity and transparency, and conduct our business in a fair and honest manner based on our joint moral compass. The principles and rules of conduct as laid down in our Company Code are at the basis of this.*

#### **Core values**

*We are passionate about what we do, we work together with our clients and stakeholders, we seek to constantly improve ourselves and we are a trusted neighbour. We are regarded as a conscientious and reliable partner.*

#### **Laws and regulations**

*We comply with all applicable laws, rules and regulations wherever we do business.*

This CSR is mainly developed for business in the Netherlands. For employees of the PoR who are involved in international activities (for example in Indonesia), dilemma-trainings are organised to deal effectively with dilemmas they encounter when doing business abroad. After all, in other countries other laws and social norms may apply but the principles of the PoR must be kept in mind. (PoR Annual report, 2018) Examples of such dilemma's arising from international activities can be found in [Appendix A](#).

The Company Code of the PoR describes that PoR wishes to do business with parties which maintain high standards regarding ethically responsible behaviour. Like 45 other countries, the Dutch ministry of Foreign Affairs endorses the “OESO-guidelines for multinationals”. The PoR also endorses these guidelines which stand for: human rights, employment and industrial relations, environment, combating bribery/bribe solicitation and extortion, consumer interests, science and technology, competition, taxation. These guidelines provide non-binding principles and standards for responsible business conduct in a global context consistent with applicable laws and internationally recognised standards. (OECD, 2011) In the international strategy of the PoR, the following is stated about the CSR-statement and risk management:

*In participating in international activities, PoR always focuses on corporate governance including the CSR policy. Integrity and transparency characterize our way of working. PoR respects the people, the environment, culture and legislation where we operate. PoR aims for strengthening the economy in combination with improving the living environment. PoR carries out the Dutch values with respect to human rights, child labour, discrimination, gender equality, safety, employment, sustainability, corruption and integrity. Furthermore, the Port Authority seeks to tie in with the prevailing Dutch government-policy.*

*In addition, all international activities are tested for potential risks. This involves not only the financial risks but also the political, economic, legal and reputation risks. For the major projects, a risk register is maintained from the start, and mitigating measures are taken. Where necessary, this is tested by independent parties. (PoR International, 2018)*

This part of the International strategy already underscores the risks of participating in international activities. Nevertheless, several global trends and developments are the reason for PoR to act on an international level:

- The PoR has a good international reputation which reflects on the companies situated in the port area and the Dutch maritime and hydraulic engineering sector. Although the PoR is dropping in the world ranking of largest international ports, qualitatively the PoR is still the international leader in the field of infrastructure and port management. This means that the PoR must continue to play an active role internationally in order to maintain that reputation.
- This also means that the PoR needs to strengthen its position by following the shift in world trade towards other continents.
- Within the Hamburg-Le Havre range the Mediterranean ports are developing rapidly. Consequently, the PoR needs to strengthen its position by cooperating with other port in the Netherlands.
- Cooperation with international ports is important to maintain the leading position in the field of energy transition and innovation.

The international strategy further states that all international activities and participations need to contribute to the mission of the PoR. If the PoR participates in an international port projects, the PoR bears risks for operational and commercial performance of the port, based on a long-term involvement. The decision of investing in large infrastructural projects is only based on solid business cases, with the right risk-surcharges per country and per project, and only if the risks are limited to capital in the joint venture (for which PoR is not financially liable). (PoR International, 2018) The department within the PoR ‘Port Development’ also has its own sub-objective:

“The port-industrial complex needs to be developed efficiently, safely and fit for the future. Transport and industries need to be accommodated in harmony with the existing surroundings, by using the available area optimally.”

Within this department the above-mentioned vision, annual report (CSR), and international strategy of the PoR is checked among the employees. The employees were also asked to give their opinion about participating in international projects. The results of this opinion poll and the discussion afterwards with the CEO Allard Castelein can be found in [Appendix B](#) ‘Corporate governance PoR’.

## 2.2. United Nations Sustainable Development Goals

As can be seen in the annual report of 2017 of the PoR, the UN Sustainable Development Goals (UN-SDG) form the foundation to achieve the written goals. The seventeen goals of the United Nations serve as a reference for sustainable development in all countries of the world.



Figure 5 United Nations Sustainable Development Goals (United Nations, 2015a)

Because of economic and social value for the PoR, the following UN-SDG are the most relevant according to the annual report of 2017 focussing on the port in Rotterdam itself: 3) Safety is the main priority in the PoR. Besides, PoR wants to create a healthy and attractive living environment. 7) PoR wants to develop its port in a sustainable way creating a place where energy transition is stimulated. 8) PoR stands for socially responsible employment. The PoR creates about 195.000 jobs. 9) By improving its infrastructure, PoR wants to strengthen the competitiveness of the current sectors present in the port. In addition, PoR wants to attract new sectors.

Sustainable growth in the port is an important mission of PoR but can only be achieved if the following UN-SDG are also considered as important<sup>2</sup>. These UN-SDG are still not mentioned as important in the annual report of 2017:

**6)** Around the port, the water quality must be ensured. For example, dumping water which has been used for cooling can have major impact on the ecology and drinking water for communities nearby. Besides, oil leakage may also have major impact on the water quality. Every year millions of people, most of them children, die from diseases associated with inadequate water supply, sanitation and hygiene. Not only from drinking the water, but also from eating the food affected by poor water quality.

**11)** Port activities attract people to live near the port. The city/community around the port must be sustainable. A city needs for example a good infrastructure network to prevent congestion. Cities need to enable people to advance socially and economically.

**13)** Action against climate change must be taken. 171 countries adopted the Paris Agreement to limit global temperature rise to well below 2 degrees Celsius, and given grave risks, to strive for

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<sup>2</sup> Expert opinion [Appendix B](#), 2018

1.5 degrees Celsius. Effects of climate change are changing weather patterns, rising sea level, and more extreme weather events.

**14)** The world's ocean drives global systems that make the Earth habitable for humankind. It is therefore important to conserve and sustainably use the ocean while developing a port. The sea regulates and provides rainwater, drinking water, weather, climate, coastlines, food and even oxygen. At the same time, oceans have played a vital role for trade and transportation.

**15)** When developing a port, forests must be managed sustainably. Deforestation will lead amongst others to loss of biodiversity. Forests cover 30% of the Earth's surface providing food and shelter, counteracting climate change, and the homes of indigenous population. Every year 13 million hectares of forests are being lost.

**17)** Partnerships will strengthen the means of implementation of the goals. This requires coherent policies, an enabling environment for sustainable development at all levels and by all actors, and a reinvented global partnership for sustainable development. (United Nations, 2015a)

### 2.3. IFC Standards

The International Finance Corporation (IFC World Bank Group) standards and guidelines are often used as benchmark by International and Bilateral Finance Institutions. The key process elements of an Environmental and Social Impact Assessment (ESIA) according to the IFC generally consist of:

1. Initial screening of the project and scoping of the assessment process
2. Examination of alternatives
3. Stakeholder identification and gathering of environmental and social baseline data
4. Impact identification, prediction and analysis
5. Generation of mitigation or management measures and actions
6. Significance of impacts and evaluation of residual impacts
7. Documentation of the assessment process (i.e. ESIA report)

Large port development projects generally fall in 'Category A-projects' according the IFC's policy on Environmental and Social Sustainability Policy Statement of January 2012 (World Bank Group, 2012). Category A-projects are '*business activities with potential significant adverse environmental or social risks and/or impacts that are diverse, irreversible, or unprecedented*'. The following performance standards apply to category A-projects: (RHDHV ToR ESIA, 2017)

- **PS 1: Social and Environmental Assessment and Management Systems**  
Within a social and environmental assessment, identify the negative and positive impact of feasible alternatives (including the no project alternative). Recommend mitigation measure to reduce negative impact and enhance benefits.
- **PS 2: Labour and Working Conditions**  
Labour and working conditions must be managed well to maintain worker commitment and retention. Economic growth through employment creation should be accompanied by protection of the fundamental rights of workers.
- **PS 3: Pollution Prevention and Abatement**  
Pollution prevention and abatement are key elements in the project. Increased economic activity often generate increased levels of pollution to air, water and land. Not only on regional level, but also globally.
- **PS 4: Community Health, Safety and Security**  
Avoid or minimize the risks and impacts to community health, safety and security that may arise from project related activities.

- **PS 5: Land Acquisition and Involuntary Resettlement**  
Land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers to both physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets).
- **PS 6: Biodiversity Conservation and Sustainable Natural Resource Management**  
Biodiversity needs to be protected and conserved by maintaining ecosystem services. This is fundamental to sustainable development. Important habitat for bird and marine biodiversity in the project area are indicators of the importance of sustainable natural resource management.
- **PS 7: Indigenous People**  
Indigenous people, groups with identities that are distinct from mainstream groups in national societies, need to be protected. These people are often among the most marginalized and vulnerable segments of the population. Based on the IFC definition, the definition 'indigenous people' generally refers to a distinct social and cultural group.
- **PS 8: Cultural Heritage**  
Cultural Heritage must be protected during project activities. If there are important heritage sites near the project site, like graveyards, this must be included in the ESIA. (RHDHV ToR ESIA, 2017)

In addition to the IFC Performance standards, in 2017, the IFC World Bank Group set up the Environmental, Health, and Safety (EHS) guidelines. The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice, which is defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of project under similar conditions globally. Important to note is:

"When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment." (World Bank Group, 2017)

The most common EHS issues associated with port and terminal construction are:

- Terrestrial and aquatic habitat alteration and biodiversity
- Climate change resilience
- Water quality
- Air emissions
- Waste management
- Hazardous materials and oil management
- Noise and vibration (including underwater)

These issues and accompanying standards will not be elaborated on in further detail since these standards mostly applied to specific industries situated in the port. This is not the scope of this research.

IFC operations contribute to several UN-SDG mentioned in the previous section, where number 1 'no poverty' and 'reduced inequality' are overarching goals. At the strategic sector level IFC promotes investment and advisory projects in infrastructure, agriculture, financial inclusion, health and education, aligned with UN-SDG 2, 3, 4, 6, 7, and 9. Across sectors and regions, IFC seeks to promote employment creation and economic growth, gender equality, environmental and social sustainability and climate change adaptation and mitigation, aligned with UN-SDG 8, 5, 12, and 13 respectively. IFC stimulates partnership with private investors to mobilize new sources of finance which is aligned with UN-SDG 17. (IFC, 2018)

The 'Equator Principles' are a set of voluntary standards that commit the above-mentioned IFC-PS, adopted by financial institutions. These principles ensure that the financed projects, are developed in and implemented in a manner that is socially responsible and environmentally sound and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. (RHDHV ToR ESIA, 2017)

When PoR is part of an international Project Organisation abroad, an ESIA (IFC-PS 1) must be created according to international standards in order to: (PoR International, 2016)

1. Attract international funding & tenants to the port-industrial complex. International investors and banks usually require an international ESIA
2. Avoid project delays and cost overruns. A successful ESIA avoids court cases and expensive changes at later stages of the project
3. Ensure stakeholder support. Thorough consultation shows stakeholders that we take their concerns seriously. This can turn opponents of the project into supporters
4. Avoid reputation damage. An international project can only be delivered when clients, shareholders and stakeholder place trust in the project PoR is involved in.

## 2.4. Building with Nature guidelines and philosophy

To achieve the UN-SDG (and IFC standards) a paradigm shift is needed from “building in nature” to “building with nature”. This innovative approach is called the Building with Nature (BwN) approach, where the natural system is taken as a starting point for a design. BwN uses natural processes to achieve a solution, which in some cases can lead to lower costs on a lifecycle basis than conventional engineering solutions. Rapid societal and environmental changes make sustainability and adaptability increasingly important in hydraulic engineering projects. BwN attempts to meet society's needs for infrastructural functionality, and to create room for nature development at the same time. The BwN philosophy encourages the hydraulic engineer to take a sustainable, sometimes innovative approach, thereby often creating functional solutions beneficial to multiple stakeholders. The goal of BwN is to focus on opportunities and win-win solutions, thereby thinking out-of-the-box. This requires evaluating the long-term costs and benefits of different multi-functional alternatives, which makes it complex. In BwN projects there are several key governance issues which asks for a proper stakeholder management. (Ecoshape BwN Guidelines, 2018)

To make a BwN design working, project planning guidelines need to be used and clear targets must be set. An example of such a target is the amount of wave reduction, and how to realise this wave reduction. A BwN solution will not be successful when it is applied on the wrong location, with wrong environmental conditions. In other words, it will only be a workable solution, when the solution is implemented in a right way. BwN knows five principles: (van Wesenbeeck BwN Lecture, 2018)

1. System scale perspective, only at a large scale the solution may be effective
2. Risk and benefit assessment of full range of solutions, structural and non-structural combinations
3. Standardized performance evaluation
4. Integration with ecosystem conservation and restoration
5. Adaptive management (monitoring)

Before thinking about a BwN solution, first the ecosystem services need to be identified. These ecosystem services form the connection between nature and society and are defined as the benefits acquired by human kind from ecosystems. In 2005 the Millennium Ecosystem Assessment provided guidelines for the application of the concept of ecosystem services in planning and design. The Millennium Ecosystem Assessment grouped the ecosystem services in four categories:

1. Provisioning services
2. Regulating services
3. Cultural Services
4. Supporting Services



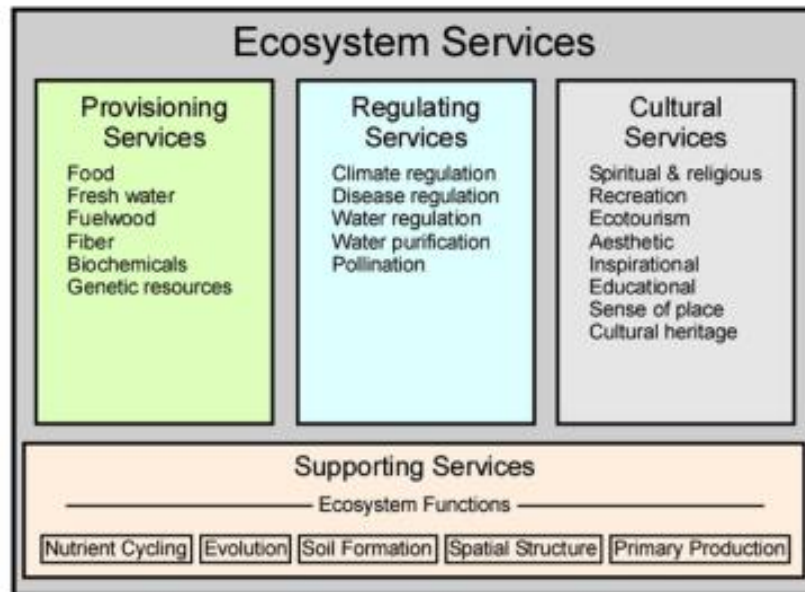


Figure 6 Ecosystem services in four categories by The Millennium Ecosystem Assessment (Ecoshape BwN Guidelines, 2018)

To explain the ecosystem services of a natural system, sandy shores are taken as an example:

As *Provisioning services*, society gets **fresh water** as rain water filtrates into the dunes sand creating a fresh water aquifer. **Food**, as fish and shellfish caught commercially. **Construction material**, beach sand collected for construction works and in the past coastal grass for weaving utensils, wood from dune forest. **Energy**, possible from wind, waves and even algae.

As *Regulating Services*, sandy shores serve as **coastal protection** against flooding and erosion. **Water regulation**, filtering and clearing the water which is also beneficial for agricultural uses. **Sediment transport** restores the coastline after being disturbed by for example a storm.

Cultural services are non-material services, like **tourism** and **recreational activities** such as swimming, surfing and sailing. **Research and educational** benefits since coastal system are important subject in scientific research. The **aesthetic** value of beaches and dunes make sandy coast an attractive place to live and houses are more expensive. **Reflection and spiritual enrichment** at the coast, sounds and sunset.

Supporting services enable the services of the other three categories. Basically, these services provide the boundary conditions. **Habitat provision** for animals and plants such as refuge and forage area for different species of wading shore birds. **Wave dissipation**, since beach and foreshore attenuate waves providing more quiet conditions close to land. **Soil formation**, providing dune vegetation to grow and develop.

Traditional projects do not pay enough attention to the supporting ecosystem services. Consequently, many infrastructural projects have a negative impact on nature, undermining the systems integrity, sustainability and resilience.

**Fact:** Natural assets of the coastal zone have suffered worldwide over the last three decades, 50% of salt marshes were lost or degraded, at least 35% of the mangroves have disappeared and 30% of coral reefs has vanished. (Ecoshape BwN Guidelines, 2018)

BwN is paying full attention to the supporting services in particular, in order to achieve sustainable development. The basic idea is that natural processes are not only complied with but are also used and stimulated so that infrastructure fits sustainably within the natural environment and new opportunities for nature are provided.

Basically, the BwN design process knows five steps which can be followed in any phase of the project realisation process:

Step 1. Understand the system (physical, socio-economical and governance) and define objectives

Step 2. Identify realistic alternatives

Step 3. Evaluate the qualities of alternatives and pre-select an integral solution

Step 4. Elaborate selected alternatives

Step 5. Prepare the solution for implementation in the next phase on the road to realisation

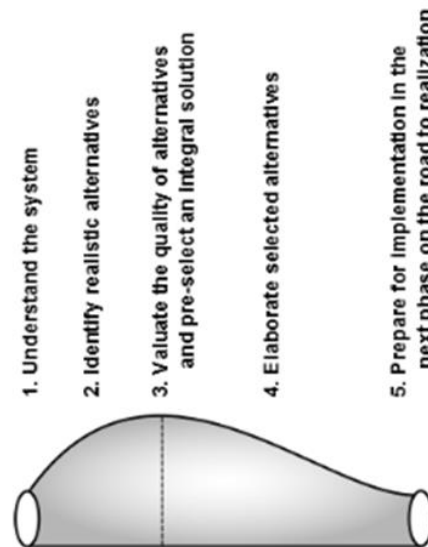


Figure 7 Five basic steps for generating BwN Design ideas (Ecoshape BwN Guidelines, 2018)

The alternatives may be illustrated using sketches (artist impressions) that qualitatively indicate the geographic location of economic functions and ecosystem services and the way these two are integrated. The five steps describe in Figure 7 can be applied throughout the project realisation process, but as the project develops, the potential impact of the BwN solution will decrease. In Figure 8, the blue lines indicate the funnel, the narrower the funnel, the lower the potential impact of the BwN solution and the smaller the degrees of freedom. The project life cycle phases are:

1. Initiation phase
2. Planning and design phase
3. Construction phase
4. Operation and maintenance phase

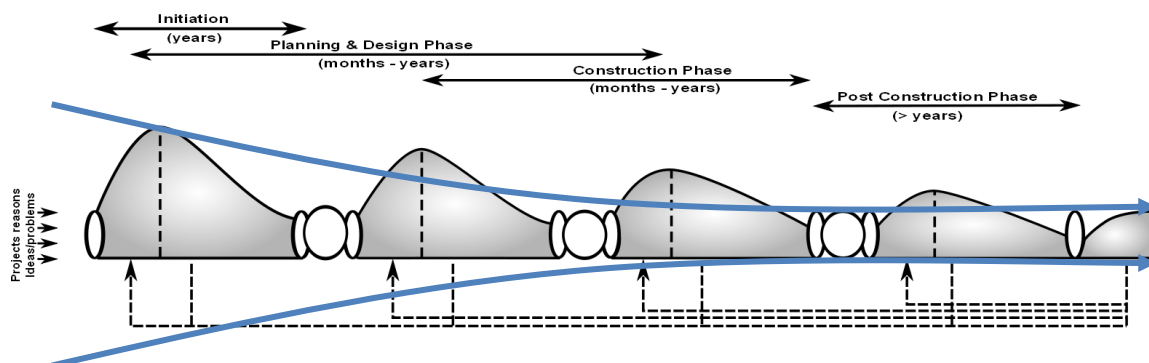


Figure 8 Overview of the project realization phase, blue lines indicating funnel. Adapted from (Ecoshape BwN Guidelines, 2018)

### Governance

BwN designs need to be supported by society if they become reality. This requires integrated design criteria across scales, sectors and time horizons which makes it complex. Several governance issues may arise from the BwN approach. It is crucial to involve (knowledge) organisations and networks which support the BwN solution to gain trust among the society. This is part of the Stakeholder Network Management which describes amongst others the proper way to communicate BwN plans to stakeholders and the wider public. A good start for applying the BwN philosophy is to find out what (contemporary) issues, problems and challenges are on the political and societal agendas. The local society and government will be supportive when the BwN solution solves one of these local issues (or issues arising from the project). In this way the earlier mentioned “win-win solution” is created, and the focus has shifted from the negative impact of the infrastructural project to the positive impact on nature and society. (Ecoshape BwN Guidelines, 2018)

## 2.5. Conclusion: developing an evaluation framework

To determine whether participating in an international port project confirms to the international standards, several experts of the PoR were consulted. Their opinion was compared with the published vision, International Strategy, the CSR-statement and strategy stated in the annual report of the PoR. The Annual report of 2017 also refers to the UN-SDG, the UN Global Compact and the OECD-guidelines for multinationals. These goals and standards show overlap with the goals of the BwN philosophy, which stands for an innovative sustainable approach for infrastructural projects where ecosystem services play a crucial role in the design process. The BwN guidelines and philosophy can serve as a tool for realising the UN-SDG.

Four of the in total seventeen UN-SDG are mentioned in the annual report as the most important UN-SDG for the PoR. These goals are: ‘good health and well-being’, ‘affordable and clean energy’, ‘decent work and economic growth’ and ‘industry innovation and infrastructure’. In the ideal situation all seventeen goals are strived for. The IFC standards and guidelines are set up by the IFC World Bank Group and used by International and Bilateral Finance Institutions to determine if the business activities are according to international standards. The Performance Standards (PS) are more general while the Environmental, Health, and Safety (EHS) standards are more industry-specific. Moreover, these standards contribute to the UN-SDG.

When a company participates in an international port project, host country regulations and standards may differ from the international standards. The IFC-EHS states that projects are expected to achieve whichever is more stringent. If less stringent standards or measures than provided in the IFC guidelines are appropriate, in view of specific project circumstances, a justification is needed which should demonstrate that the choice is protective for human health and the environment. When ‘decision-making dilemmas’ arise, PoR organises “dilemma-trainings” to discuss how to deal with contradictory standards.

Most of the discussed international standards and vision of the PoR overlap each other. By summarizing these standards and related requirements, an evaluation framework is formed which can be used to determine how a conventional port projects can be carried out in a more sustainable way according to international standards (See first three columns of [Chapter 6](#)). In addition, the BwN guidelines are added to this evaluation framework since these guidelines can change the approach of the design process resulting in a different view on the project goals. The third column shows a port-related illustrative example of a measure to meet the requirements. In the next chapter, this evaluation framework will be applied to the current master plan of the PoKT.

Note that in practice it is not realistic to strive for a project which satisfies all goals and standards of the framework. It serves as tool to identify opportunities to change the view on a project. These standards can be seen as the boundary conditions under which a project should be developed, not as explicit goals of the project. In the evaluation framework, the standards are categorised in four parts: financial (blue), social (red), environmental (green) and governance (purple). The standards which are related to the design (pre-construction) phase of a port development project are encircled with a dotted line. The other standards are related to the implementation (operation) phase when the basic infrastructure of the port is already realised. In this chapter the relevant standards for international port projects and sustainable development are identified, and an evaluation framework is developed.

# 3 Evaluation of the current master plan of Kuala Tanjung

To evaluate the impact of the current master plan of the PoKT, first a description of the port system situated at North-Sumatra in the Batubara region is given. In addition, the stakeholders in this region are analysed. Subsequently, the status and port requirements of the port development project at KT will be explained. This includes a commercial, technical, socio-economic, and financial analysis of the current master plan. The terms of reference for the Environmental and Social Impact Assessment (RHDHV ToR ESIA, 2017) are used to determine the impact and suggested mitigation methods which can be used to identify opportunities for improvement. Finally, the PoKT project is evaluated by applying the evaluation framework of the previous chapter (see [Chapter 6](#)).

## 3.1. Port system

Figure 9 shows the project area indicating the rivers, the mangrove forests (green) and the tidal mudflats (orange) which follows the -5 mCD depth contour. This graph also shows the topography and existing infrastructure in the area. First, the river system and bathymetry along the coast are described. Secondly, the expected areas of influence (system boundaries) are evaluated encompassing regional impacts.



Figure 9 Project area including tidal mudflats, mangroves, rivers and villages (author)

### 3.1.1 Bah Bolon river

This river is one of the many rivers that drain North-Sumatra towards the east and runs through the site area. All other rivers shown in Figure 9 are its tributaries (Bagan, Tanjung, Mati, Kuba/Gambus Laut river). The water catchment area is named the Bah Bolon watershed which reaches all the way to Lake Toba in the middle of North-Sumatra and discharges into the Strait of Malacca. The river is very shallow and is typically about 50 m to 100 m wide close to the coast. The river system consists of a lot of bifurcations and confluences. Because of the many palm oil

plantations next to this river and the cohesive banks, the course of the river is quite stable. Besides, the velocities in the river are low because of the relatively flat downstream part. Most of the rainfall, about 1500-3000 mm/year, falls in September to November. The highest average monthly precipitation (260 mm) is about 3 times larger than the lowest average monthly precipitation (90 mm), so it is expected that the difference between the lowest and highest discharge of the river has the same ratio. In August 2016 a methodological survey showed a maximum discharge of 200 m<sup>3</sup>/s, but this was measured during spring. Part of this discharge is seawater which was brought in by the tide and flew out during measuring. Further inland the discharge could be lower. The river provides fresh water for irrigation, water supply, waste water discharge, aquaculture and fresh water supply for mangroves. The river feeds the coast with nutrients and sediments. (RHDHV, 2017b)

### 3.1.2 Bathymetry

The system is characterised by a nearshore tidal flat (green area) with a deep channel, seawards of this, running parallel to the coast as can be seen in Figure 10. The minimum distance to the -5 mCD contour (dark blue) is about 800 m offshore from the shoreline northwest (NW) of the headland (blue arrow) reducing to 550 m at the headland and extending to 1,200 m offshore southeast (SE) of the headland. When elevations refer to Chart Datum (CD) it can be seen as the level of the Lowest Astronomical Tide (LAT). In section 4.2.6 [Water levels](#) this will be explained. The -10 mCD contour (light blue) lies between 800 and 1,500 m offshore. There is a shoal area (dark blue) about 2 km offshore the headland with a least depth of -2 mCD. The nautical chart indicates that the seabed comprises sand and that there are numerous fish traps in this area.

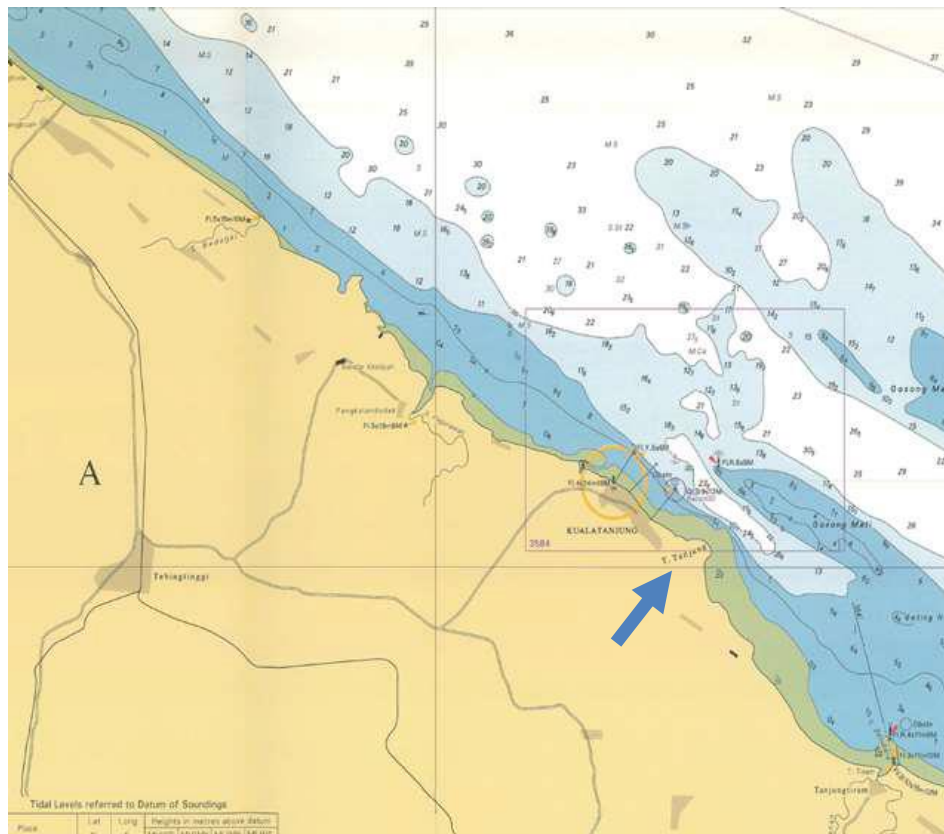


Figure 10 Nautical chart showing bathymetry at KT area & approaches (RHDHV ToR ESIA, 2017)

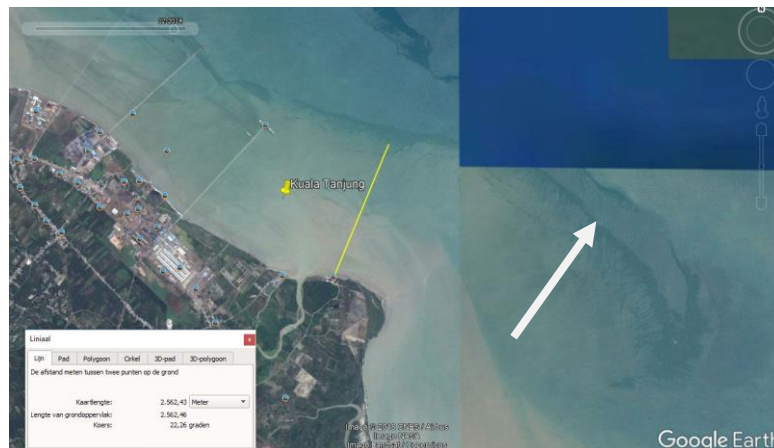


Figure 11 Google Earth image 2014 showing the deep trench (white arrow). Yellow line  $\approx$  2,5 km

Deepwater (> 30 m deep) lies about 14 km to the NW (white). Deepwater also lies about 12 km to the ENE; however, this is seaward of the shoal area. There is no information available on the navigation approach used by the ships using the existing jetties of PT Wilmar (palm oil) and PT. INALUM (aluminium). However, it may be assumed that the navigational approach from the Strait of Malacca to these jetties is from the NW, with the ships turning to the berth. There is an opportunity with the new port development to locate berths alongside the deep channel offshore. In the course of this research the depth contours of the “Technical Note stage 1” are used. (RHDHV, 2017a)

### 3.1.3 Areas of influence

The port system (white rectangle in Figure 12) not only affects the area of construction but can also have influence on the migratory routes of birds and fish. Furthermore, access roads and railways to Medan, the capital city of North-Sumatra, and more inland the SEI Mangkei Special Economic Zone (where palm oil is produced) will also cause social and environmental impact. The Batubara region provides various habitats to: vertebrate species such as birds (IBA)<sup>3</sup> and fish, bivalves such as clams and mussels, and crustaceans such as shrimps and crabs. In Chapter 4 [The Building with Nature approach](#), the port system will be elaborated upon and divided in a physical and ecological system to get a better understanding of the natural processes, ecology and biodiversity.

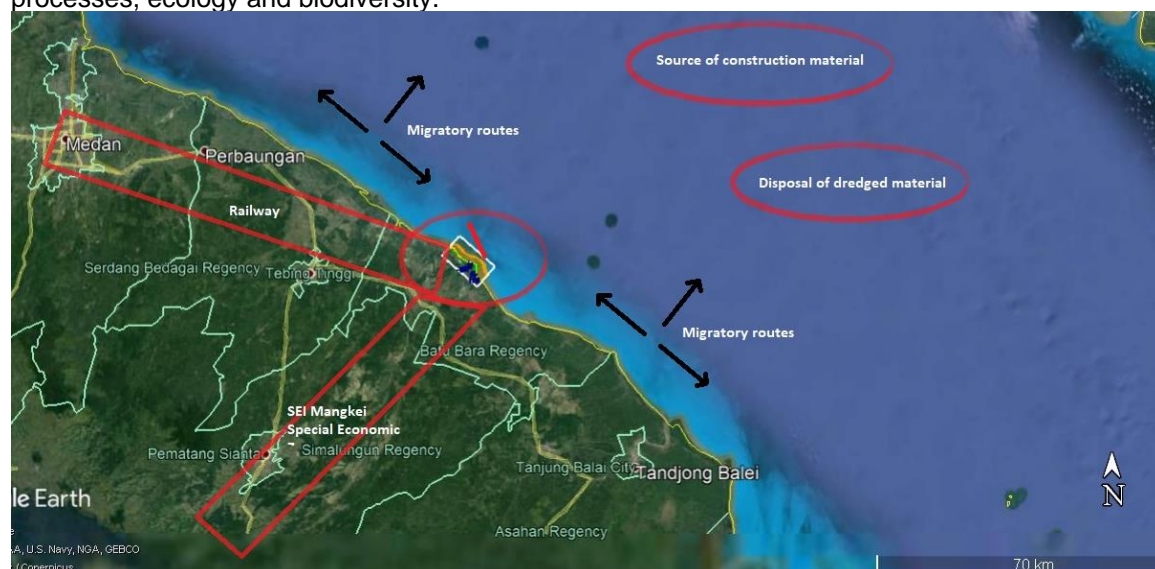


Figure 12 Areas of influence (author)

<sup>3</sup> Important Bird and Biodiversity Area (IBA) designated by Birdlife International (RHDHV ToR ESIA, 2017)

### 3.2. Stakeholder analysis

The Batubara region has a population of around 400,000 people and is not far away from the 4<sup>th</sup> largest city of Indonesia, Medan. KT is probably sufficiently close to Medan to unlock trade, but sufficiently far away to be outside Medan's congestion and urbanisation zone. As mentioned in 3.1.3 [Areas of influence](#), not far away from KT, the SEI Mangkei Special Economic Zone is located. The Trans-Sumatra toll-road and rail which is under construction will make the transport between Medan, Sei Mankei and KT possible. At KT there are already some port activities and a multipurpose terminal (jetty) is under construction. The two stand-alone facilities can handle about 2.5 million tons of palm oil (Wilmar) and aluminium (Inalum) annually.

Stakeholder involvement is important to create coherence between the stakeholders during the project. Poor stakeholder involvement could undermine the potential positive effects of government-supported projects like PoKT project. A stakeholder analysis must be done to have a clear overview of the stakeholders involved during all the phases of the project. Organising a joint secretariat between the project organisation and Batubara Authorities should be a high priority not only for stakeholder engagement but also for the practical reason concerning legal and local political support. (RHDHV ToR ESIA, 2017)

According to the IFC's handbook on stakeholder engagement (2007) stakeholders are defined as 'persons or groups who are indirectly affected by a project, as well as those who may have interest in a project and/or the ability to influence its outcome'.

The complete project development of the current master plan falls within three sub-districts (Figure 13) and four villages:

- Fishing community 'Kuala Indah' at Bah Bolon (Bagan) river mouth (p.8 RHDHV ToR ESIA, 2017)
- KT village, mainly populated along the main roads in Desa Kuala Tanjung
- Lalang village
- Suka Ramai village, situated between Bah Bolon river and Mati river

From the first 'town hall session'<sup>4</sup> in the region three key themes were identified:

- Residents want to protect [nature](#) because of the symbolic value of the mangroves. Besides, they were worried about the drainage water management.
- Residents see potential of creating thousands of [jobs](#) for 'their sons'.
- Residents want to know the [land prices](#) for land acquisition.



Figure 13 An indicative map of the sub-districts in the project area: Batubara region (author)

<sup>4</sup> From skype meeting with A. Neeteson PoR Indonesia see [Appendix F](#)

Other stakeholders of the KT port development project can be summarized (See Appendix C for the full list of stakeholders) as follows: each stakeholder of the sector has its own interest and influence. Therefore, the stakeholders can be categorized based on their interest and influence. This is done to understand the potential support or opposition for the project. The stakeholders from all sectors are divided into four different type of stakeholders. Each stakeholder is coded by colour. Green represents supporters, red stakeholders are opponents and orange represents neutral stakeholders (See Figure 14).

**Type 1: The blue block** represents stakeholders for whom meeting their needs is important. Engagement and consultation are done on area of interest. It is important that the level of interest of these stakeholders should be increased. Eventually these stakeholders should become part of the stakeholders in the orange block.

**Type 2: The orange block** represents stakeholders which are considered as key players. High focus on this group is important and these stakeholders should be involved in governance/ decision making bodies. These stakeholders must be engaged and consulted regularly and are involved in high risk areas.

**Type 3: The green block** represents stakeholders not considered as key players and are the least important stakeholders in the project. These stakeholders are informed via general communications, newsletters and websites. Eventually these stakeholders should become part of the stakeholders in the yellow block.

**Type 4: The yellow block** represents stakeholders who show consideration in the project. These stakeholders show interest through involvement in low risk areas. These stakeholders should be informed and consulted on area of interest.

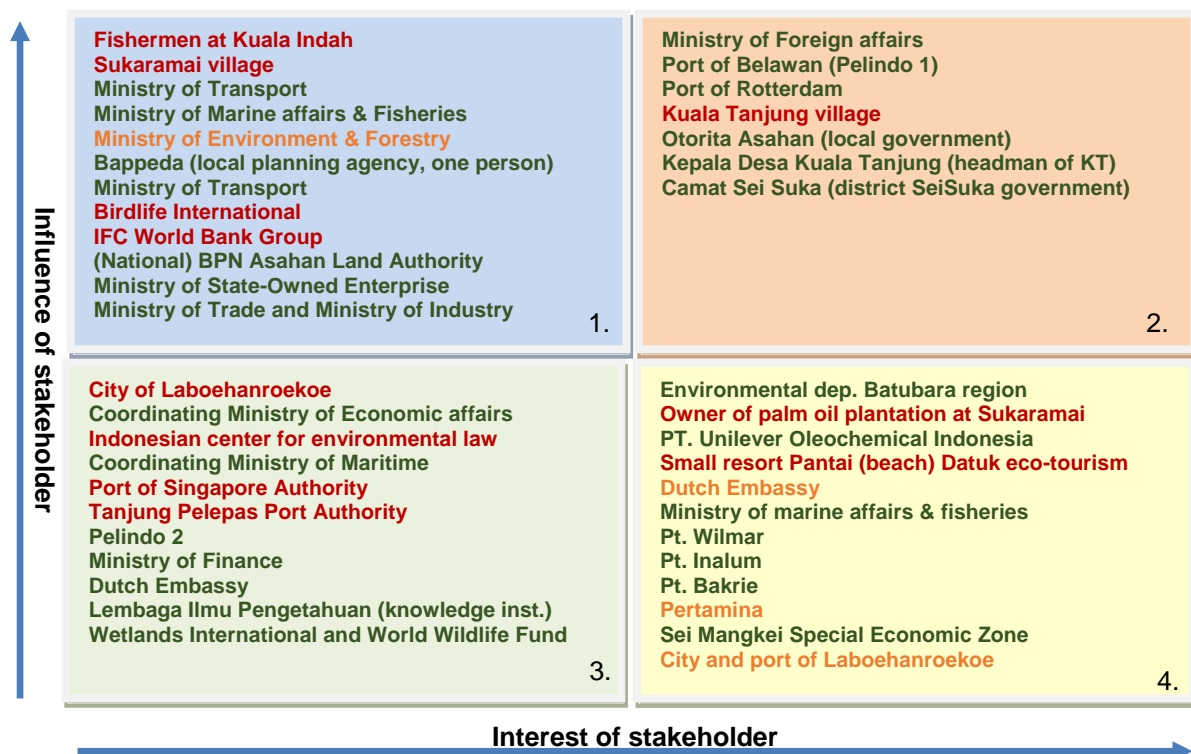


Figure 14 Stakeholders categorized based on their interest and influence (author)



### 3.3. Status of the port development

In April 2016 president Joko Widodo visited the Netherlands to formalise a maritime cooperation between the Dutch and Indonesian government with a bilateral memorandum of understanding. In Figure 15 a timeline indicates how PoR has committed itself to support the development of the PoKT.

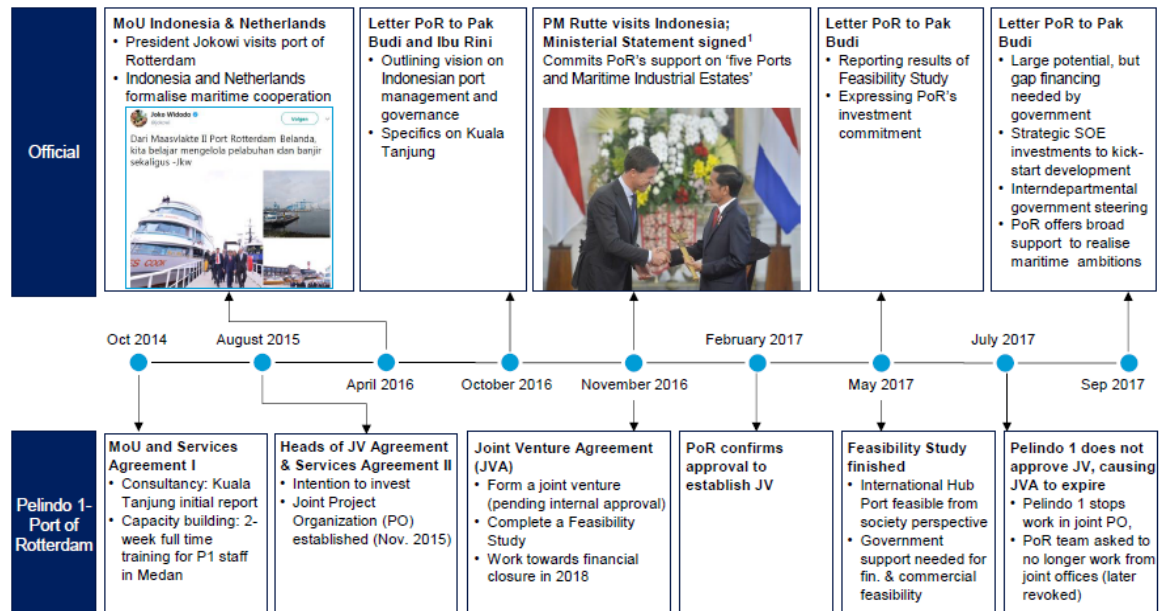


Figure 15 Timeline, Dutch government supports Indonesia's maritime agenda to which PoR has committed itself (PoR Indonesia, 2017)

In April 2018 the 'soft launching'<sup>5</sup> of phase 1 (Multipurpose terminal showed on front page of this report) started, while the jetty is still under construction. This symbolic launching was shown by serving a cruise ship at the new jetty since receiving passengers is less complicated than (un)loading cargo ships. In August 2018 three ship-to-shore (STS) cranes were installed at the jetty and eight rubber-tired gantry (RTG) cranes. In the fourth quarter of 2018, phase 1 will be completed (Bambang Eka Cahyana, President Director of Pelindo 1, 2018) and fully in operation. From this moment phase 2 (land reclamation + industrial area) should be initiated, but because of political issues the project has been put on hold. Early 2019, Pelindo 1 wants to start together with PoR on further developing the PoKT with the main goals a world-class container terminal. In section 3.3.2 **Technical analysis and design requirements** more information about the phasing of the current master plan can be found.

Now, a preliminary long-term port development plan for the PoKT has been made and a Terms of Reference report (ToR) is set up for the feasibility study of phase 2. As stated in this ToR ESIA, the preliminary lay-out is under continuous review and may change significantly in coming planning stages. In the project management stages are outlined as blocks. After every stage a go/no-go decision is planned. The project is still in the first feasibility stage.

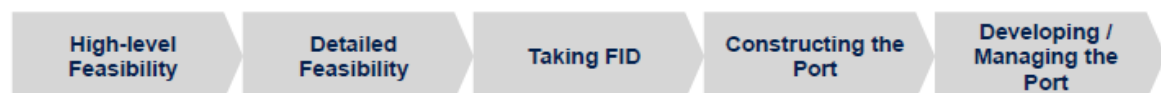


Figure 16 Project stages starting with the current Feasibility Study. FID is final investment decision (PoR Indonesia, 2017)

<sup>5</sup> According to Indonesian news-websites: <http://industri.bisnis.com/read/20180620/98/807854/dermaga-kapal-pesiar-akan-dibangun-di-kuala-tanjung> and <http://www.thejakartapost.com/news/2017/04/12/kuala-tanjung-port-to-start-operations-in-july.html>

Annual Report Port of Rotterdam 2017

*“Tijdens het bezoek van de president van Indonesië in het voorjaar van 2016 aan Nederland, tekenden beide landen een Memorandum of Understanding (MoU) op het gebied van maritieme samenwerking. Een van de onderdelen daarin betreft de ontwikkeling van havens. Vanuit zijn in 2016 opgerichte kantoor in Jakarta ondersteunt het Havenbedrijf Rotterdam de Indonesische overheid bij haar ambitie om vijf grote havens te ontwikkelen, geografisch verspreid over Indonesië. Dit doet de lokale staf, waar nodig met hulp vanuit Rotterdam, door middel van consultancyopdrachten en door investeringen in partnerships. In 2017 lag de focus op twee projecten: de ontwikkeling van Kuala Tanjung (Noord Sumatra, nabij Medan) en de uitbreiding van Jakarta Port.*

*Met betrekking tot Kuala Tanjung rondde het Havenbedrijf Rotterdam in 2017, grotendeels in partnership met het Staatsbedrijf Pelindo 1, een eerste haalbaarheidsstudie af. Deze studie laat de potentie van de haven zien, vooral ook ten aanzien van de sociaal economische waarde die zou kunnen worden gecreëerd. De studie toont ook de commerciële en financiële uitdagingen van het project. Het Havenbedrijf Rotterdam is in gesprek met de Indonesische overheid en met Pelindo 1 over de voorwaarden waaronder dit project tot ontwikkeling kan worden gebracht. De eerder beoogde joint venture met Pelindo 1 kwam hierdoor niet tot stand.”*

### 3.3.1 Commercial analysis

The PoKT is currently a small-scale industrial port with stand-alone facilities that can handle palm oil (Wilmar) and aluminium (Inalum). As mentioned before, a multipurpose terminal is being developed by Pelindo 1 for handling palm oil, containers and breakbulk (phase 1). These facilities have their own jetty and do not share infrastructure nor utilities. These existing facilities cover about 500 ha. (PoR Indonesia, 2017)



Figure 17 Current situation Kuala Tanjung (PoR Indonesia, 2017)

The port can function as a gateway (import and export), industrial port (production at port) or a transshipment port (sea to sea). In developing a port, it is difficult to start as a transshipment port, directly trying to compete with Singapore and Malaysia<sup>6</sup>. On the other hand, an industrial port will

<sup>6</sup> Interview Kees Kleinhout 7-5-2018. See [Appendix F](#)

form a steady basis for the future by generating demand for large captive bulk cargo volumes and as a result as well lots of space and infrastructure. Energy and cement are the most promising sectors in KT. (PoR Indonesia, 2017)

Pertamina is a state-owned petrochemical enterprise that has a monopoly position in North Sumatra. There is private sector interest, but this makes it difficult for these private parties to invest without offtake agreement or co-investment with Pertamina. Pertamina owns almost all crude oil refineries in Indonesia and has a dominant position in downstream fuel retail. Besides Pertamina, other port-related industrial segments need to be attracted to the port of KT. Potential segments are: Petrochemicals (Pertamina), Metals (Krakatau, Inalum), Energy (Inalum and Sumut 2 expected to be coal-fired power plants), Cement (Semen, using MPT phase 1) (PoR Indonesia, 2017)

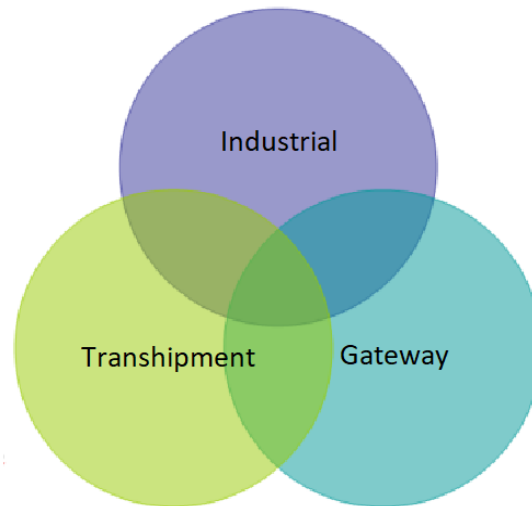


Figure 18 Three port functions for Kuala Tanjung (author)

After developing an industrial cluster (Figure 18), the port can serve as an efficient gateway port to serve the hinterland of North Sumatra (including Sei Mankei). The port can also serve as an export hub for other provinces (e.g. Aceh, West Kalimantan). There should be a joint strategy to develop both KT and Sei Mangkei optimally. (PoR Indonesia, 2017)

In the long term, the goal of the Indonesia government is that the PoKT can function as a transshipment port by having a large container terminal (phase 3). (RHDHV ToR ESIA, 2017)

### 3.3.2 Technical analysis and design requirements

In the final phase of current design two breakwaters are included and land reclamation is required. The breakwaters provide shelter for the 24/7 terminal operations and form a base and access road for exposed jetties and for sheltered jetties (smaller ships). Land reclamation is required to provide enough access to deep water for large container vessels and to locate the container stacking area directly behind the quay. In addition, river diversion and resettlement are needed for realising the design. River diversion is required to provide large plots for industry and terminals and to avoid discharging sediment from the current river into the port basin. Resettlement is required to obtain land for the large-scale industrial complex but also to ensure the safety of the residents of KT. (RHDHV, 2017a)

The first phase (MPT) is already being developed by Pelindo 1 (see front page of this report) and is indicated as a green jetty in Figure 19. In phase 2 (Figure 19) the first breakwater is constructed with conveyer belts and jetties to receive ships. This breakwater can serve a coal-fired power plant (Sumut 2), steel industry (Inalum) and eventually a cement plant (Semen Indonesia). These berths will not be sheltered from the prevailing wave climate and therefore some operational downtime may be expected. (RHDHV, 2017d)

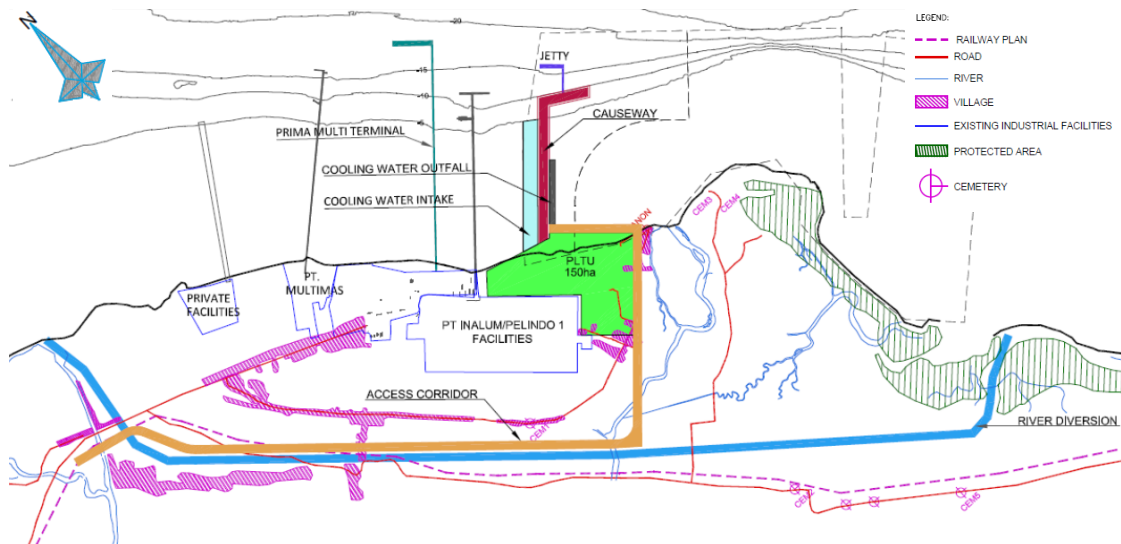


Figure 19 Phase 2 development (RHDHV, 2017a)

In phase 3 (Figure 20) it is assumed that heavy industries will establish in the port complex requiring the unloading of either dry or liquid bulk materials and the loading of dry or liquid bulk products. The current plan is based on the establishment of a refinery which would then form the basis for the development of downstream petrochemical industries. In this third phase the Bah Bolon river must be diverted, and residential area must be resettled. The NW (left) breakwater will be extended until the -10 mCD depth contour.

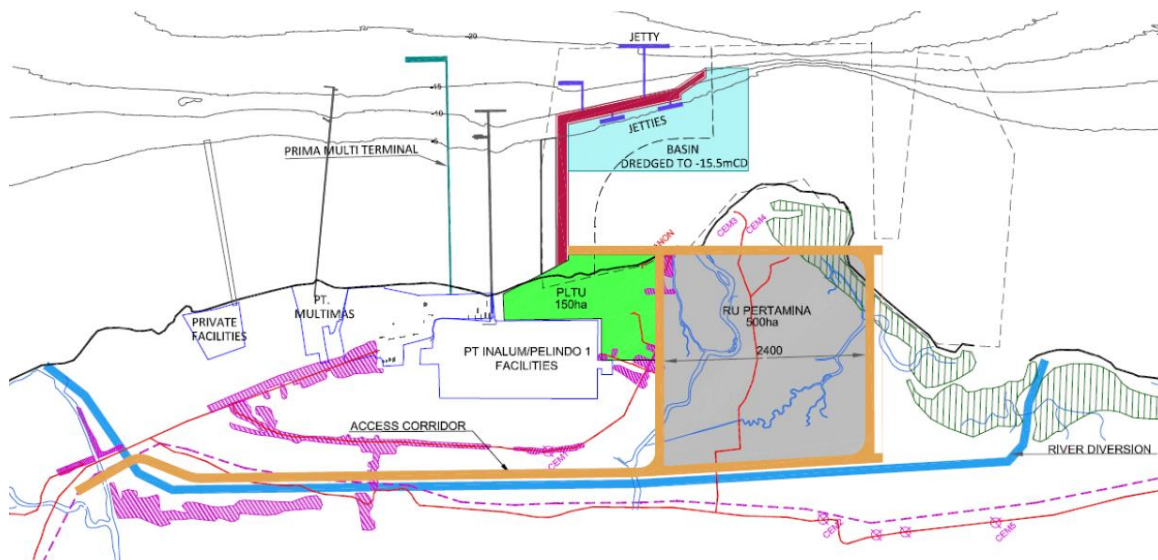


Figure 20 Phase 3 development (RHDHV, 2017a)

Phase 4 (Figure 21) comprises the development of a break-bulk and/or container terminals. Land for the terminals will be provided by the reclamation of the offshore area on the SE (right) side of the first breakwater. Phase 4 may be developed at the same time as or before phase 3.

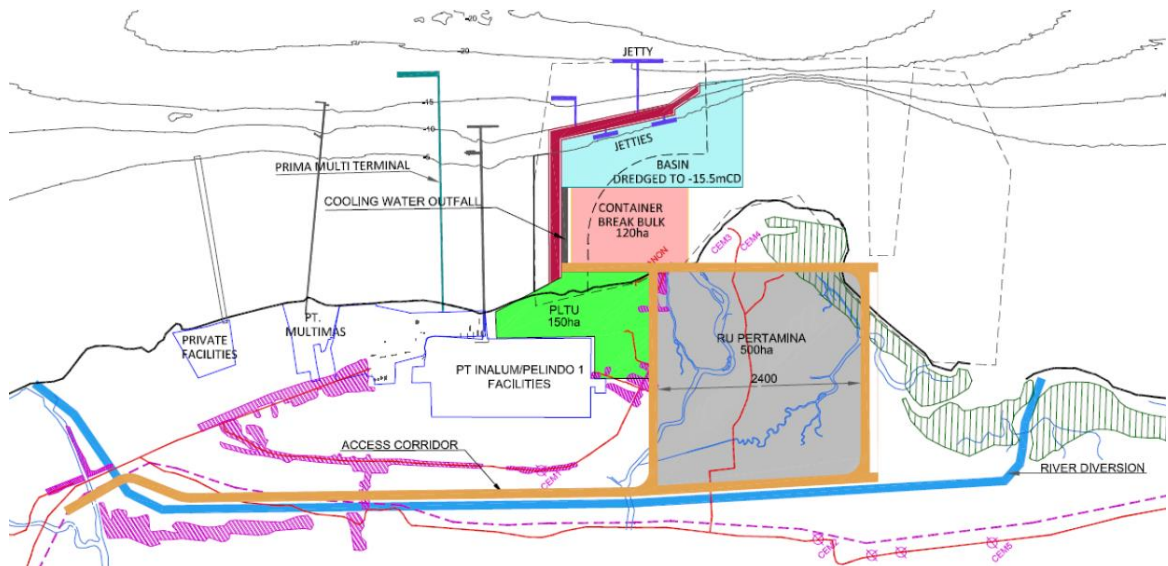


Figure 21 Phase 4 development (RHDHV, 2017a)

In the final phase (phase 5 in Figure 22) the second breakwater will be constructed, and the world-class container terminal will be realised. The breakwater with jetties will also accommodate ships (liquid bulk). This phase includes the land reclamation and dredging. After this phase there is space for a refinery, steel plant and other industries. These terminals will extend the port complex in the SE direction (right) until the right breakwater. (PoR Indonesia, 2017)

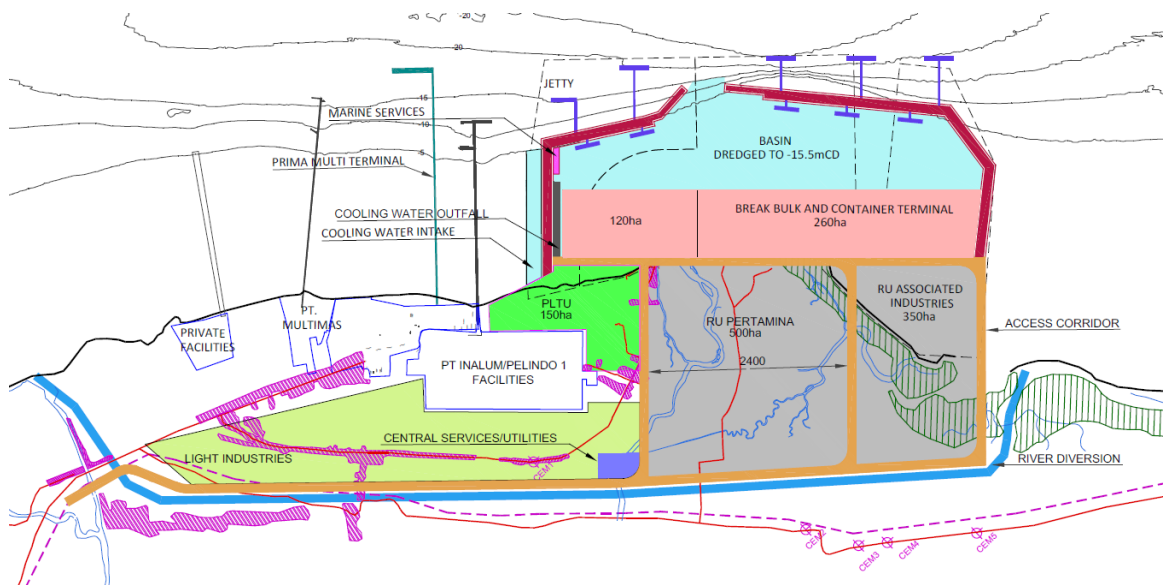


Figure 22 Proposed final phase technical design with internationally competitive container terminal (PoR Indonesia, 2017)

In Table 1 a summary of the current design requirements is shown.

Table 1 Design requirements compiled with available documents of RHDHV (RHDHV, 2017a)

Design Aspect	Design requirement	Size
<b>Terminals</b>		
Multipurpose	Containers, Break Bulk, Palm Oil	70 ha.
Breakbulk and/or Containers	24/7 operational (no downtime), protected by breakwater in harbour basin and container stacking area directly behind the quay	390 ha. (first part of phase 4: 120 ha.)
Dry bulk	For unloading coal from large bulk carriers. These may be jetty type of structures. Buffer storage (at power plant) may be located some distance from the berths with coal transferred by a system of conveyers. Panamax and smaller must be berthed in a sheltered harbour basin.	-
Liquid bulk	Buffer storage tanks at some distance from the berth with the bulk liquids transferred through pipelines	-
Liquid bulk ships (unloading)	Unloading crude oil in large crude carriers (VLCC ships) (May be jetty type structures)	20.5 m draught
Liquid bulk ships (loading)	Loading refined product to Suezmax or Panamax tankers, (May be jetty type structures) Panamax and smaller must be protected by breakwater in harbour basin	17.0 m draught
<b>Industry &amp; services</b>		
(Pertamina) refinery unit (RU) – phase 3	Design requirement	Size
	Close to dry/liquid bulk 400,000 bbl/day, cooling water supply (100 litres/bbl),	500 ha.
Power plant (PLTU) – phase 2	Thermal power station with 2x660MW including transformer yard, coal storage and handling system, seawater cooling system, laydown area and storage. The power station will require seawater intake and outfall for cooling.	100 ha.
Fly ash storage	Next to power plant	50 ha.
Manufacturing and food processing industries	-	-
Light industries	-	-
Marine services	Land area for towage, pilotage, oil spill response, bunkering, garbage collection. Berths for tugs, pilot boats, launches, barges and possibly a bunkering tanker. A marine control centre, oil spill response centre, maintenance workshops and a small slipway will be required.	6 m draught
Access corridors	Access corridors will be required for the following: roads (2x2 lanes) including drainage, road lighting and fencing, railway permanent way, service corridor for pipelines for liquids/gas/feedstock/industrial water supply, conveyors for dry bulk materials, service road, drainage and utilities.	50-100m width
<b>Total port area &amp; industrial estate</b>		<b>~ 3000 ha</b>
<b>Basin</b>		
Depth in basin	Design requirement	Size
	Dredging	-15.5 mCD (for 1.0 m under keel clearance)
Basin width	$1.5 \text{ LOA} + 2 \times B =$	500 to 720 m
Turning area diameter	$1.5 \text{ LOA} =$ (assuming tug assistance)	600 m

Outside breakwater	Design requirement	Size
Max. depth	Without dredging	-17.0mCD (min. Panamax ships)
Access channel depth	Minimum dredging for Malaccamax vessels	-26.0 mCD
Access channel width	1-way VLCC and 2-way panama vessels	300 m
Dredging and land reclamation	Design requirement	Size
Total estimated quantity of dredged material	Approach channel + NW harbour basin + SE harbour basin	80.5 million m <sup>3</sup>
River diversion estimated excavated material for canal	See Figure 19	~7.9 million m <sup>3</sup>
Total estimated reclamation fill quantities (offshore)	Total estimated land reclamation of ~632 ha.	~64.2 million m <sup>3</sup>
Difference between total estimated quantity of dredged material and estimated fill	No requirement. This number may be useful in the course of this study. For nourishing the mangrove system at the mudflats or store it somewhere to settle and dry for later use.	~24.2 million m <sup>3</sup>

Table 2 Maximum significant wave height per type of ship (RHDHV, 2017a)

Type of ship	Limiting wave height $H_s$ in metres	
	0° (head-on or stern-on)	45–90°
General cargo	1.0	0.8
Container, ro/ro ship	0.5	
Dry bulk 30 000–100 000 dwt loading	1.5	1.0
Dry bulk 30 000–100 000 dwt unloading	1.0	0.8–1.0
Tankers 30 000 dwt	1.5	
Tankers 30 000–200 000 dwt	1.5–2.5	1.0–1.2
Tankers >200 000 dwt	2.5–3.0	1.0–1.5

Source: Thoreson, 2011

### 3.3.3 Environmental and social analysis

International standards need to be applied during the ESIA process to resolve the environmental and social issues. Until now international standards are not applied and a structured and transparent dialogue with residents has not started. Pelindo 1 and PoR have decided to invite an international AMDAL review, but current practice continues to deviate from international standards. Well organised environmental and social management is needed to gain trust of the world-class companies, international lenders and of course to avoid losing support from residents. (PoR Indonesia, 2017)

The measures which are expected to have the highest impact are: river diversion, resettlement (alternative livelihood for fishermen), breakwater construction and dredging & reclamation. Land acquisition turned out to be the highest risk factor for project delay in Indonesia<sup>7</sup>. There are three

<sup>7</sup> Research done by World Bank: 'World Bank Land Acquisition Research in Indonesia' and <https://www.indonesia-investments.com/news/todays-headlines/land-acquisition-issue-limits-development-of-indonesias-toll-roads/item1808?>

small villages (Indonesian: 'kampungs'): KT village, Kuala Indah village and Suka Ramai Village (last one only final phase). (PoR Indonesia, 2017) This asks for proper stakeholder management.

As described in section 3.1. **Port system**, the project area includes: an important bird area, mudflats, protected forest and mangroves. Intervention in the river system downstream will also have an impact on the river conditions upstream. (RHDHV ToR ESIA, 2017)

The current phase 3 design foresees development at exactly an area that is currently residential. This will probably cause delay in the starting date since acquiring land where people currently live is far more complicated than acquiring 'farm land'. There is also non-residential land available not far away, so it will be difficult to argue for phase 3 why that land cannot be used. (Pelindo 1 & PoR, 2017)

Looking at the area needs in phase 3, it is difficult to justify the river diversion in phase 3. The social and environmental impact of this measure will be large. Diverting the river will deeply change the water conditions of the current delta and it moves the impact to an area outside the current project area, which implies environmental impact on a much wider mangrove area. The livelihoods of people living along the river must be restored and the impact on the mangrove area must be minimised. In the current plan an access road will go through dense residential areas for at least 10 km. This leads to noise, congestion and safety issues. A road to the south-west as an access to the Sei Mangkei (Special Economic Zone) would go through palm oil plantations only, leading to less impact. (Pelindo 1 & PoR, 2017)

### 3.3.4 Socio-economic analysis

Governmental goals are: lower logistics costs, develop value-added manufacturing, attract international investments, generate employment and boost economic situation outside Java. But above all, the main governmental goal is to develop an international hub port.

The PoKT project needs a positive business case to be a bankable project but phase 2 and 3 of the project has a negative NPV of USD ~141 million. To bridge this financial gap governmental support is needed. This can be done by accelerating investments in state owned enterprises (SOE) in the PoKT, or by lowering the costs for the joint venture by taking public infrastructure off the balance sheet of the joint venture, and by accepting lower returns (lower the risk). The last one can be achieved by lowering the cost of debt by funding part of the investment through a state-owned bank at non-commercial rates. (PoR Indonesia, 2017)

### 3.3.5 Financial analysis

The PoKT project does not have a bankable business case without non-commercial financing. This makes the project unfeasible for PoR as it is now. NPV of the whole project development is negative as can be seen in the conceptual business case (~50% accurate). (PoR Indonesia, 2017) Included as capital expenditures are the breakwater, land reclamation, dredging, river diversion, quay walls, onshore land improvement, roads and drainage. Land acquisition and client related infrastructure (i.e. jetties, pavement, drainage, conveyer belts etc.) are not included in the CAPEX. As CAPEX and enabling works, land reclamation, dredging, quay walls the and construction of the breakwaters are the most expensive ones. The operational costs for the project concerns maintenance, insurance and organizational costs<sup>8</sup>. The model excludes a concession fee to the government.

According to the Economic Impact Assessment (Rebel, 2017) the fully developed port (Industry Max scenario) has a strong potential for economic value creation. About 90.000 direct and indirect jobs can be created and the added value is estimated to be EUR 1.4 billion. The above-mentioned investments are in total EUR 311 trillion. (Rebel, 2017)

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<sup>8</sup> Industrial port case studies (benchmarks): Rotterdam, Singapore, Mailiao and Sohar (last two developed in last two decades)



### 3.4. Conclusion: applying the evaluation framework

Looking at the port system at the Batubara region and the port development plan, the impact of the project can be identified. The river diversion and resettlement form the main bottlenecks in the initial design of phase 2 and 3. Also the cost estimates and conceptual business case show the difficulties in financing the project. From a commercial point of view market studies and market soundings show opportunities, but there is still no land acquisition strategy. Until now, a brief conversation with the Batubara Authorities and Pelindo 1 has been taken place, but local stakeholder management is still not initiated.

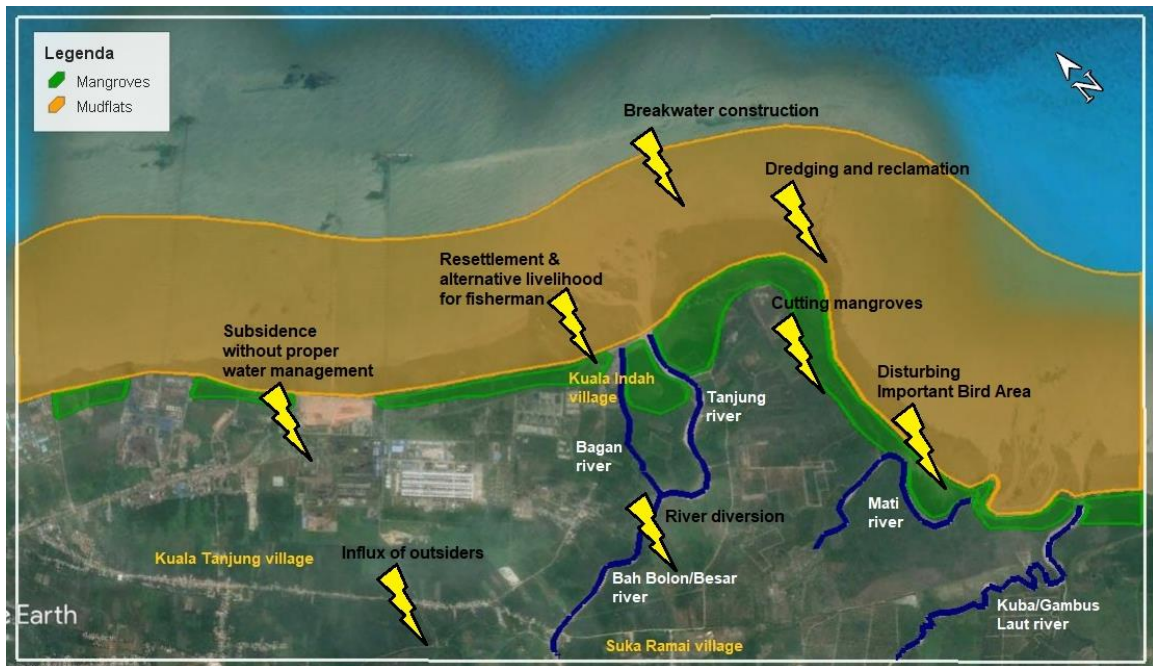


Figure 23 Measures in current master plan with highest environmental and social impact (author)

The PoKT project is a traditional project where first a functional design is made, and afterwards the social and environmental issues are identified. In the ToR for the ESIA several preliminary mitigation/enhancement/monitoring suggestions are given. From this impact analysis 41 issues are indicated as negative impact and 6 as positive. The following issues and suggestions [between square brackets] per 'potential source of impact' stand out the most:

#### SOCIAL

##### Permit and socialization activities without proper stakeholder management:

- Residents may be confused from which areas may be evicted by the project. [clear stakeholder engagement]
- Residents may be enthusiastic for potential job opportunities and increase in local economic activity but may also feel worried if jobs are reachable for them.

##### Land acquisition and resettlement of residents at the project footprint:

- Residents may be concerned about changes in their livelihood. [avoid resettlement as much as possible]
- Residents may be concerned about asset valuation of their land: fruit trees, fishing ponds, buildings, businesses. [create a clear and fair acquisition plan guaranteeing fair prices]

##### Influx of outsiders/migrants and urbanization:

- Residents may be concerned about cultural changes. [prepare spatial planning for urbanization with local planning office Bappeda and apply CSR programs to enhance community relations]
- Public roads may not be able to support the population. [prepare spatial planning for urbanization with Bappeda, including railway]
- Additional infrastructure for land and sea has positive impact for residents.

**Security and safety disturbance:**

- Increase in security and safety disturbance for residents. [prepare security plan with local police]

**Changes in river morphology by river diversion:**

- Other fishing grounds may be used by wider fishing community leading to disruption to local fisheries, where river is used as fresh water fishing ground and habitat of marine fish larva. [ecological monitoring of river and coastal habitat and sponsor post-harvest fish training]
- Disturbance of river transportation, many trading points such as informal ports called Tangkahan. [maintain transportation function of river]
- Risk of flooding of residential areas because drainage without a river may not be enough. [arrange drainage system for residential areas]

**Loss of agricultural land:**

- Agricultural land will be lost for affected households. [assign new land/compensation for these households as proper compensation]

**Loss of heritage sites:**

- Some World War II ruins (bunkers) are present and numerous commentaries are positioned along the main road in KT. [consultations with local archaeological and cultural office]

**ENVIRONMENTAL****Changes in river morphology by river diversion:**

- Water level upstream may change resulting in disturbance of river as habitat for freshwater fish and freshwater biota and habitat of marine fish larva. [river ecology study to determine current situation]
- Disturbance for coastal protection. [draft replanting program if mangroves are damaged, programs should not be a one-time deal, should be multiple species, and follow natural succession of mangrove habitat]
- Reduction of sediments entering coastal process, resulting in risk of coastal erosion and affecting mangroves. [design detached reclamation to avoid river diversion or decrease river disturbance]

**Water quality disturbance:**

- During construction phase but after all in the industrialized area when the port is finished. [follow threshold regulation and proper monitoring plans]
- Loss of benthos (all organisms living on the bottom of rivers/seas) in the dredged areas and under reclamation area. [design deck on piles or jetties to avoid this]

**Subsidence because of ground water extraction:**

- Industries and urban area extracting deep groundwater as a source of fresh water will result in subsidence of the port industrial area causing flooding (see Figure 24). [force the industries to use piped water as a source and construct a proper sanitation network]



Figure 24 Port of Semarang (Java, Indonesia) flooding of the container terminal ([www.zonamagz.com](http://www.zonamagz.com))

#### Changes in coastal morphology and functions:

- Disturbance of mudflats and mangroves as a habitat for birds (IBA), mammals and terrestrial animals at coastal/mangrove area. [maintain current mangrove/coastal area and strengthen by replanting certain areas. Involve community groups and NGO's]
- Risk of coastal erosion when mangroves are cut down. [draft replanting program if mangroves are damaged, programs should not be a one-time deal, should be multiple species, and follow natural succession of mangrove habitat]

#### Sea water quality disturbance from port and industrial area:

- Turbidity increase from dredging, sand sourcing and potentially blasting. [follow threshold regulation and monitor turbidity]

#### Greenfield area disturbance from port and industrial area:

- Additional construction and operation of road and railway access causing emissions of pollutants to air, soil and water noise, light and vibrations. [avoid protected area by choosing proper routing and discuss plans with local planning office Bappeda]
- Converting greenfield into constructed area may cause drainage problems and if reclaimed areas are higher, the existing land may flood. [make proper drainage design and discuss impact on watershed with Bappeda]
- In case of blasting and/or piling: disturbance of marine mammals. [assign new green compensation areas for these mammals]
- Source of sand, stones and other construction materials. [determine and study the sand/dredging material source]

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The impact of the current plan on the environment of KT is large. Most of the suggested measures are mitigation or compensation measures. The river diversion is the source of impact where still major issues arise from. In addition, it is still unclear whether there is enough sand available for the planned reclamations. In the current master plan, the importance of the delta, which forms the interface between salt and fresh water, is mentioned several times. Also, the importance of the mangrove area for biodiversity and coastal protection is stated. The proposed solution for damaging the present mangroves is drafting a replanting program where mangroves are damaged. The given requirements of this program: [it should not be a one-time deal, it should involve multiple species, and follow natural succession of mangrove habitat](#). In the current master plan this program is not elaborated upon or incorporated in the design. In addition, it is mentioned that beneficial uses should be sought for the disposal of material dredged from the Bah Bolon river diversion, the approach channel, and harbour basins. This is also not incorporated in the current master plan.

In [Chapter 6](#) (column four), the evaluation framework is applied to the PoKT development. The standards, related requirements and examples of measures to meet the requirements, are set up in [Chapter 2: Standards for international port projects and sustainable development](#). The fourth column shows whether the current master plan of the PoKT meets the indicated standard (YES or NO). If the standard is not applicable to the PoKT or not within the scope of this research it is indicated as Not Applicable (NA). Standard 2, 6, 7, 11, 15, 17, 18, 19, 20, 22, 23, 25, 26, 27, 28, 30, 31, 34 and 36 are not met in the PoKT development project.

The current master plan of Kuala Tanjung does not yet meet all requirements stated in the evaluation framework of the previous sub-question. It is concluded that the master plan of the PoKT was mainly driven by functional requirements and economic growth, while trying to mitigate and compensate the negative consequences. These opportunities for improvement are now identified and kept in mind for answering the next sub-question.

# 4 The Building with Nature approach applied to Kuala Tanjung

In the previous chapter, it was concluded that the current master plan of the PoKT does not fit within the BwN philosophy and that several dilemmas may occur regarding the international standards. The current master plan process is traditional, since the design is mainly based on functional requirements and forecasts. The drive for sustainable port development requires a shift from the traditional approach to the BwN approach. By applying the BwN approach new solutions may be identified, and win-win opportunities may arise. Instead of focussing on the negative impact, the question is now: how to create more positive impact and win-win situations? This results in multi-objective landscape designs on a conceptual level.

## 4.1. Project in relation with the BwN timeline

As described in the previous chapter, the PoKT project is in the initiation phase where a first feasibility study is executed. This means that the project location (KT) is already fixed but most design choices are still reversible. In improving the current master plan, it is important to identify these fixed design choices and identify what impact the proposed BwN solution can have. In section 2.4. [Building with Nature guidelines and philosophy](#) the BwN design process and funnel are already explained. In every phase it is possible to implement the BwN approach, but the further the project has developed the smaller the potential positive impact of the BwN solution. The red arrows in Figure 25 indicate the path of changing a traditional design into a BwN design. For example, the arrow the most to the right (in the construction phase) indicates that the BwN philosophy can only be applied limited, as a way of minimising the negative impact. The other arrows show that there are still enough degrees of freedom to apply the BwN design philosophy.

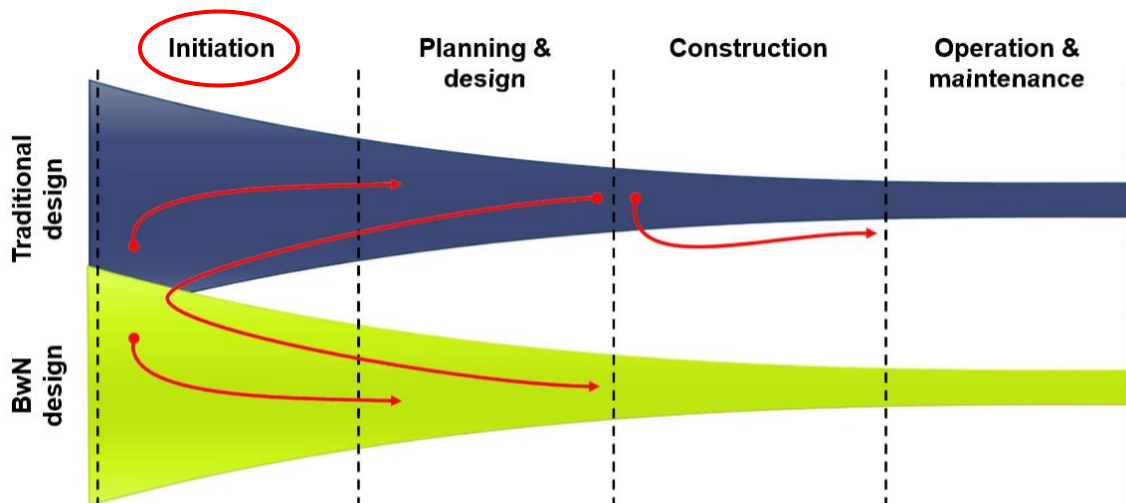


Figure 25 Funnel of a project: the narrower the funnel, the more difficult to go back in the process<sup>9</sup>

In general, there are three main points of view during a project: nature, governance, and the project itself. The BwN approach requires to look at nature first, before starting with the other two perspectives. The previous chapter about the PoKT project forces to look from the project point of

<sup>9</sup> Guest Lecture BwN on Design basics by Prof. dr. ir. Mark van Koningsveld, 25 May 2018

view but in this chapter the BwN philosophy will be applied which implies a better understanding of the natural system first.

Because the PoKT project has been put on hold, there are at the moment enough degrees of freedom to create a BwN solution. Nevertheless, there are some fixed design choices:

- Location at KT, see 3.1. [Port system](#) (Batubara region) expansion possibilities to the SE.
- Phase 1 multipurpose terminal (see front page of this report)
- Functional requirements given in Table 2 (terminal area, type of ships etc)

Reconsidered but is decided to be fixed after 4.6. [Alternatives for port development](#):

- Construction of breakwaters to ensure 24/7 operation of the breakbulk and container terminals (otherwise 25% downtime for container vessels and 6% downtime for coal barges [Annex 8 – initial downtime assessment])

In 3.1. [Port system](#) an introduction to the system was given by describing the rivers and bathymetry. To identify the ecosystem services provided by the natural system, the physical and ecological system need to be studied first.

## 4.2. Physical system

Figure 26 shows the locations of 10 marine boreholes and 10 boreholes on land as part of a preliminary geotechnical investigation of the project area. This graph also shows the topography and existing infrastructure in the area.

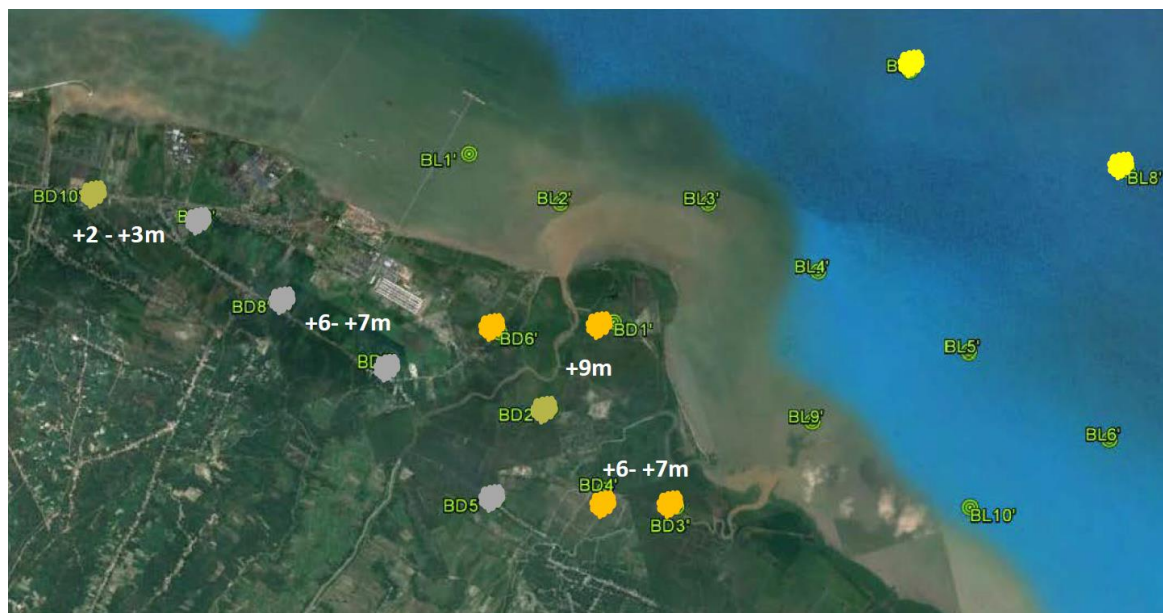


Figure 26 Locations of the boreholes and indication of the elevation of the area in mCD (RHDHV, 2017a)

### 4.2.2 Geotechnical data

At the project location there are only preliminary findings on geotechnical data. The onshore area consists of 2-3 m superficial layer of very loose to loose sand/silty sand (orange part left in Figure 27). Underneath this layer about 15 m of very soft to soft clay/silty clay/clayey silt (yellow) can be found. Again deeper, about 20 m of soil consists of medium to dense sand/silty sand overlaying 4-5 m of medium to stiff clay/silty clay/clayey silt (green) on top of medium to dense sand/silty sand. (RHDHV, 2017a)

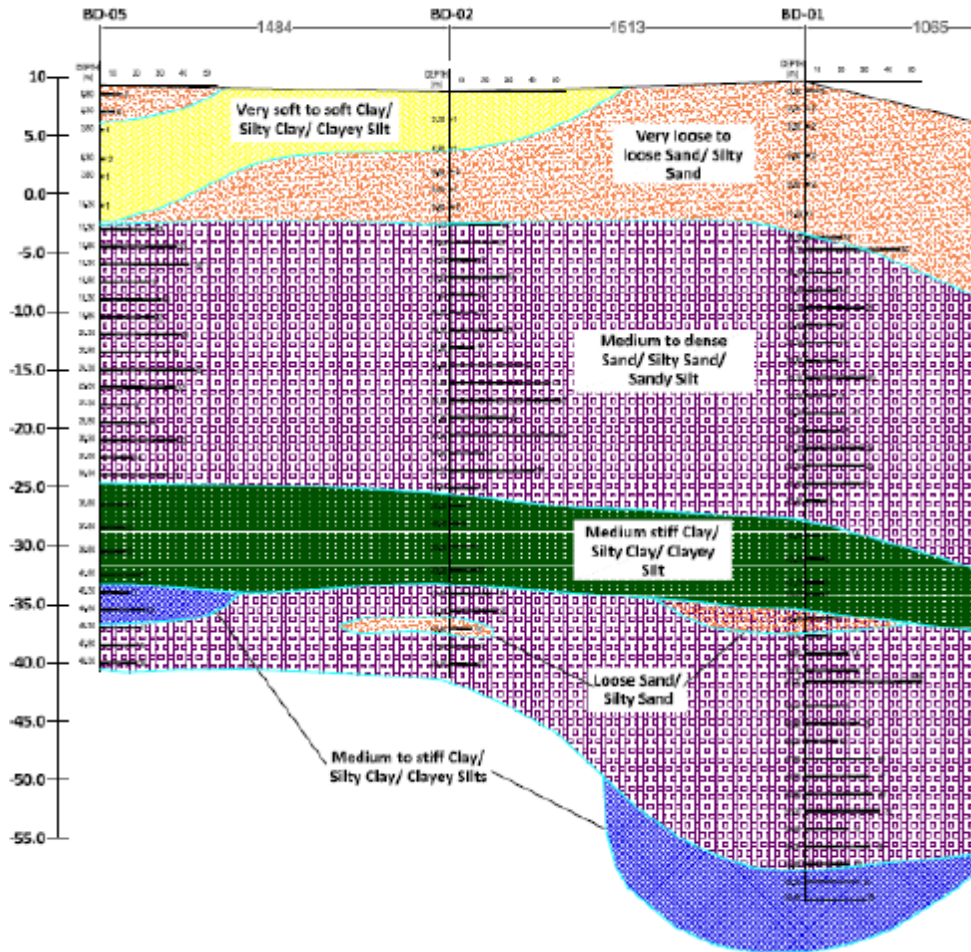


Figure 27 Geotechnical profile perpendicular to coast from headland (BD-05 is land, BD-01 is headland) elevation in mCD on vertical axis (RHDHV, 2017a)

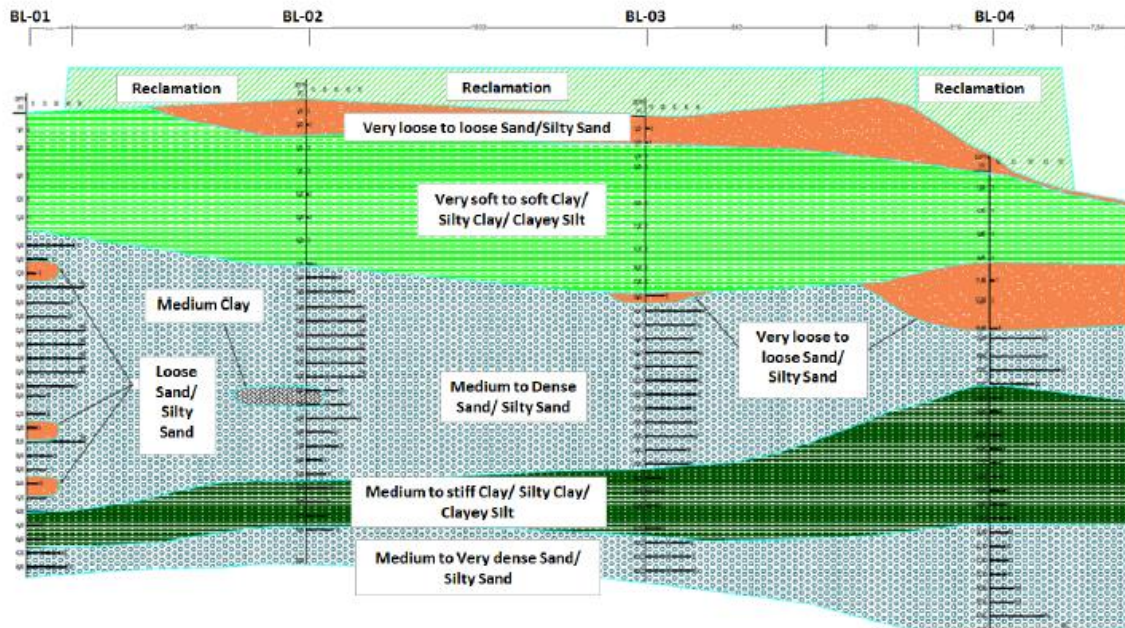


Figure 28 Geotechnical profile parallel to coast: BL-01 is NW, BL-05 is SE (RHDHV, 2017a)

As can be seen in Figure 27 and Figure 28, the mudflats mainly consist of silt and clay. The general soil conditions comprise alternating layers of clay, silts and sands:

- Around the first 20 m below seabed is made up out of weak soils.

- Below these weak soils are layers of mostly medium to dense sands and medium stiff clays.
- Most of the boreholes show layers of around 5 m thick medium dense sand, while the deeper ones show that below that sand layer medium stiff clay is present. (RHDHV, 2017a)

More offshore the seabed comprises sand with a small amount of gravel. The nautical chart indicates that the seabed comprises mud, 'mud with shells', and stones.

#### 4.2.3 Seismicity and liquefaction potential

KT is in a seismic area where the peak ground acceleration (PGA) at the surface is estimated to be 0.25g to 0.315g. There is danger of liquefaction of saturated sand and silty sands having a relative density less than 50%. The lower limit beyond which liquefaction will not occur is about 75%. The existing soils in the area comprise some superficial deposits of loose sand (RHDHV, 2017a). The study of the seismicity is relevant for the construction phase of the breakwater.

#### 4.2.4 Coastal processes

As can be seen in Figure 29 there is likely a littoral drift from NW to SE. This is also evidenced by looking at the river mouths (6 km) north of KT where spits are formed in this direction (Figure 30). The mechanism for this littoral drift is mainly the waves from the predominant NW to NNE direction stirring up in the surf zone and transporting the clay and silts in the nearshore area. Any reclamation or solid structures built into the sea are likely to obstruct this littoral drift, which may result into accretion on the up-drift (NW) side and erosion on the down drift (SE) side. (RHDHV, 2017a) However, it is estimated that the planned construction will not lead to excessive coastline instability risks or to large coastline changes within a short period of time. (RHDHV, 2017d) Nevertheless, little is known about the mud transport perpendicular to the coast by tidal currents or the cohesiveness of the mud which result in a stable coastline, dredging in this muddy area will likely result in a sediment trap (a sink).



Figure 29 Google Earth Image 2018 showing littoral drift (white arrow)



Figure 30 Google Earth Image 2015 showing spit forming indicating a net eastward directed sediment transport

#### 4.2.5 Wind

The predominant wind direction in the Strait of Malacca is from the NW (Figure 31). The wind speed is most of the time less than 10 m/s (Bft. 5) which can be characterised as on- and offshore breezes (the limited wind speed for port operations is 20 m/s). (RHDHV, 2017a)

The wind direction changes twice a day. During night the breeze is towards the sea and during the day the wind direction is from the east (landward). This is probably related to the differences in temperature of the land and the water, because at day time the land is much warmer resulting in a landward directed wind. During the night the opposite happens. Besides the ARGOSS (metocean and weather forecasting company) data showed in Figure 31, situ measured wind data is gathered for the KT project. The latter wind rose seems to deviate from the ARGOSS data, but the differences between the mean values is however limited (0.5 m/s). (RHDHV, 2017b)

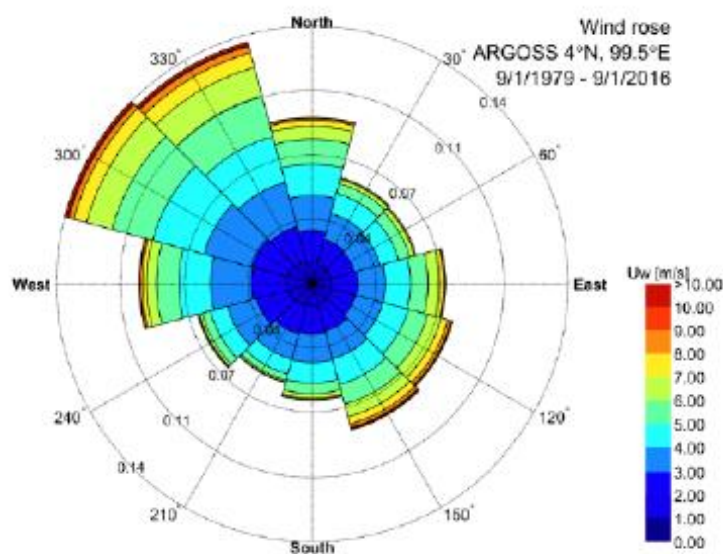


Figure 31 Wind rose ARGOSS data Jan'79 - Jan'16 (RHDHV, 2017a)



### 4.2.6 Water levels

The tide is semi-diurnal (twice flood-period and ebb-period per day) with 3 m range. Chart Datum corresponds to the 'mean lower low water line' which is indicated in the table as lowest astronomical tide.

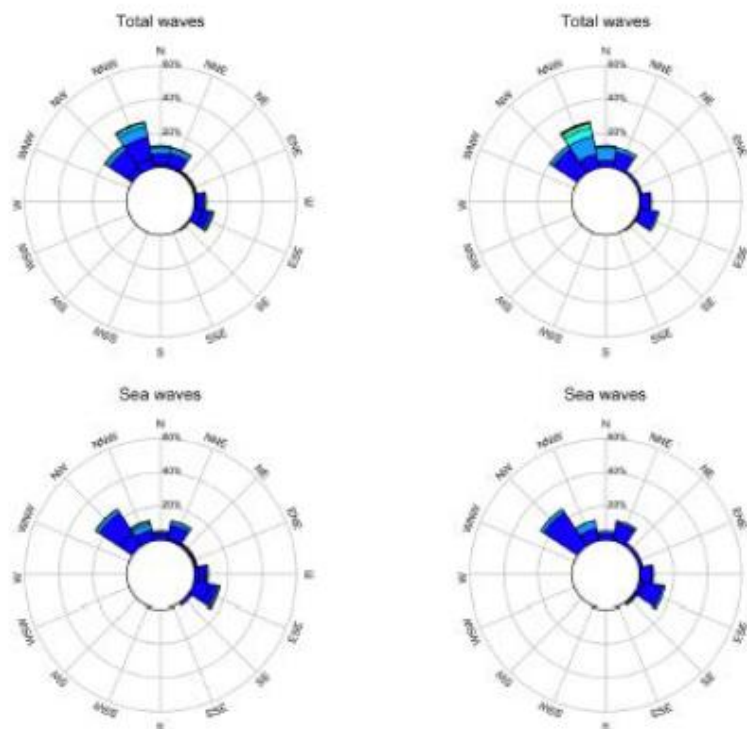
Water level		Level (m above LAT)
Highest Astronomical Tide	HAT	+2.98
Mean High Water Springs	MHWS	+2.78
Mean High Water Neaps	MHWN	+2.10
Mean Sea Level	MSL	+1.52
Mean Low Water Neaps	MLWN	+0.90
Mean Low Water Springs	MLWS	+0.19
Lowest Astronomical Tide	LAT	+0.00

Source: RHDHV Annex 2

Figure 32 Principal water levels at KT (RHDHV, 2017a)

### 4.2.7 Waves

The dominant wave direction is from the NW to NNE with local wind generated waves from E and ESE (Figure 33). The significant wave height ( $H_s$ ) exceeds 1.5 m for only 0.15% of the time. Swell waves (long wavelength) are mainly from the NNW and N sectors with  $H_s < 1.0$  m for most of the time (probability of exceedance 0.03%). The swell wave peak periods range between 4 s and 10 s. Sea waves are mainly from the NW and up to 3.2 m in height. (RHDHV, 2017a)



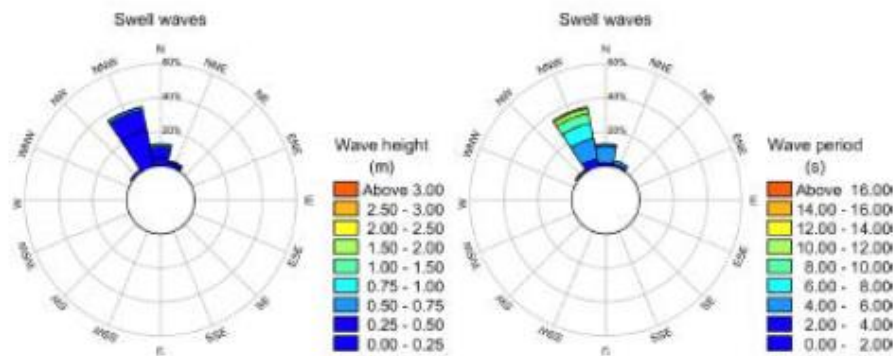


Figure 33 Wave roses for total waves (top), sea (middle), and swell (bottom) at W2 (old layout) (RHDHV, 2017a)

### 4.2.8 Currents

Offshore currents are generally aligned NW-SE and are mainly tidal streams flowing to SE during flood and NW during ebb tides creating littoral drifts. The maximum recorded current offshore was ~0.90 m/s towards the SE. Residual (ocean) current is 0.10 to 0.25 m/s to the SE.

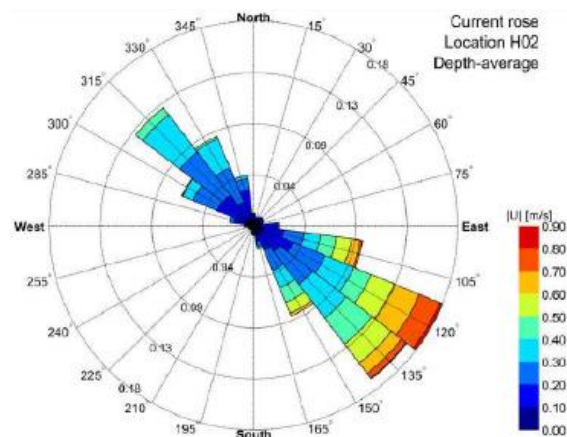


Figure 34 Rose of depth averaged currents at location H02 offshore (RHDHV, 2017a)

### 4.3. Ecological system

The Batubara region has various important habitats. There are three main habitats of concern:

- Coastal and marine habitat
- Mangrove habitat
- River and wetland habitat

#### 4.3.1 Coastal and marine ecology

The coastal area consists of a mangrove ecosystem, sandy beaches, beach vegetation and shallow water. The mangroves are scattered throughout the coast with various thickness of 5-100 m inland from the coastline (see Figure 9). Some species of mangroves noted in the area are:

- Tall-stilt mangrove (*Rhizophora apiculata*)
- Loop-root mangrove (*Rhizophora mucronata*)
- Api Api (*Avicennia alba* and *Avicennia officinalis*)
- Oriental mangrove (*Bruguiera gymnorrhiza*)
- Buta buta mangrove (*Exoercaria agallocha*)
- Nipah (*Nipah fruticans*)

In addition to these species of mangroves, beach vegetation such as shrubs (*Ipomoea pes-caprae*), and trees such as coconut trees (*Cocos nucifera*), beach hibiscus (*Hibiscus tiliaceus*) are spread along the coastal line between the sandy beaches. In Figure 35 on the right side,

migratory birds are present, and a fisherman is collecting shellfish on the flats. So, these flat are not just important for the birds (see also section 3.1 [Port system](#)), but these flats are also economically important for the local fisher folks.



Figure 35 Mangroves at the Kuba River mouth (left). Sandflats between the Kuba and Mati Rivers (right). Field survey 2016 (RHDHV ToR ESIA, 2017)

On the marine side, there is not much known about the open waters. According to ReefBase, a Global Information System for Coral Reefs, (2016) most reefs in Sumatra are located on the west coast and not on the east coast where the PoKT is situated. The closest to the project area would be at Salah Nama Island, about 40 km south east of the project area. This island is probably formed by sedimentation from large rivers. This same sedimentation may have caused the coastal waters to be too turbid for coral reefs to grow. There is still more research needed to know more about the presence of coral reefs. Because there is no data available on marine biodiversity in the area, some data on commercially important fish for local fish markets is used to study the biodiversity. This resulted in the following fish data set (Figure 36).

No.	English/Local Name	Species	General Habitat
1.	Silver croaker/Gelama	Sciaeria/Johnius sp	Coastal
2.	Banded snapper/Kerapu	Lutjanus bigutatus	Coral reef
3.	Asian mackerel/Kembung	Rastrelliger sp	Coastal & open waters
4.	Scad fish/Selar	Crumenophthalmus sp	Coastal & open waters
5.	Eel catfish/Sembilang	Plotosus canius	Coastal, estuaries, fresh water
6.	Sardinella/Tamban	Sardinella spp	Coastal
7.	Frigate Tuna/Tongol	Auxis thazard	Coastal & open waters
8.	Bluespot mullet/Ikan Belanak	Valamugil seheli	Coastal, estuaries, fresh water
9.	Mudskipper/Ikan Gelodok	Perioththalmus vulgaris	Muddy intertidal
10.	Talang Queenfish/Ikan Talang	Scomberoides commersonianus	Coastal

Figure 36 Fish caught at local fish market. Source compiled from direct field observation, AMDAL 2014 & fishbase.org (RHDHV ToR ESIA, 2017)

Despite the fish data above, it is still unclear where the fishing ground of most fisherman is located. Most of the mentioned species caught are found in the coastal waters not far from the coastline. Important to note is that these species depend on the estuaries and rivers in the area, highlighting the importance on the interface of freshwater, estuarine, and marine ecosystem on the biodiversity (and ultimately the fisheries) of Batubara. In addition to fish (vertebrates) also various bivalves (clams, mussels) and crustaceans (shrimps, crabs) are also caught by the local fisherman.

### 4.3.2 River and wetland ecology

Inland from the mangrove area, the 'river and wetland' habitat was probably once covered by peat swamp forest or freshwater swamp forest. From aerial photographs it can be concluded that most of this area is now replaced by palm oil plantation or rice fields. (RHDHV ToR ESIA, 2017)

Freshwater habitats such as rivers and wetlands are an essential part of any healthy ecosystem. The rivers do not only serve as a source of water, they also function as transport routes for villagers (Figure 37 right) and the rivers serve as habitats for freshwater species and marine species. From Figure 36 it can be seen that some fish are anadromous. This means that these fish migrate from salt to fresh water or the other way around to spawn. This highlights again the importance on the interface of freshwater, estuarine, and marine ecosystem.

The river banks of the Bah Bolon river are shallow with growth of *Cyperus rotundus* grass and *Nipah fructican* palms (Figure 37 left). The wetland area is harder to define than the river areas, while most of the area have been heavily converted into agricultural area. (RHDHV ToR ESIA, 2017)



Figure 37 River habitat at Kuba and Bah Bolon river. Field survey 2016 (RHDHV ToR ESIA, 2017)

### 4.3.3 Terrestrial ecology

Further inland from the coastal and beach vegetation, historically northern Sumatra's east coast used to be home to lush lowland with Dipterocarp trees. Also, here most of the area is converted into palm oil plantation or rice fields. As part of the ecosystem also mammals like otters and macaque monkeys live in the area. Besides, the protected water bird the Great White Egret, lives in the area (Figure 38). In the ESIA a list has been made with the vertebrate species found in the area. The data collection was focussed on vertebrates, because they are often indicator species of an ecosystem and most easily detected in the field. (RHDHV ToR ESIA, 2017)

In this list the protection status of some fauna is contradicting between national and international standards set by Government Regulation (No. 7 year 1999) and the International Union for Conservation of Nature (IUCN). The criteria are different in that a species may be rarer in the local sense but may be abundant globally. But for certain species such as the milky stork, both national and international standard agree as being protected. See also the section below on protected areas.



Figure 38 The long-tailed macaque in the mangrove area (left), and the great white egret water bird at the sand flats (right). Field survey 2016 (RHDHV ToR ESIA, 2017)

#### 4.3.4 Protected areas and biodiversity

Most of the east coast of Sumatra has a protected forest status. In addition to that, Birdlife International designated the coast as an Important Bird and Biodiversity Area (IBA). Birdlife International is a global nature conservation partnership. Meaning that this area is globally important for the conservation of bird populations. Currently there are over 12,000 IBA's worldwide and are identified by a set of internationally agreed criteria assessed by various panels of ornithologist and experts. To be listed as an IBA, a site must satisfy at least one of the following general rating criteria: (RHDHV ToR ESIA, 2017)

1. Globally threatened species: the site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable.
2. Restricted-range species: the site known or thought to hold a significant component of a group of species whose breeding distributions are restricted range
3. Biome-restricted species: the site known or thought to hold a significant component of a group of species whose distributions are largely or wholly confined to one biome.
4. Congregations: this criterion is specific to water birds and migratory birds e.g. the site is known to contain large numbers of migratory birds.

In the case of the PoKT project, it satisfies criteria number 1 and 4.

Biodiversity is a measure of the variety of organism's present in ecosystems. Biodiversity is important because it provides ecosystem services in the form of producing renewable services such as food, material and fresh water. Next to this, biodiversity provides regulatory services such as pest/disease control and climate regulation. From an anthropogenic point of view, biodiversity also provides cultural services such as value and enjoyment for humans. (RHDHV ToR ESIA, 2017)

It is difficult to gather exhaustive information about the biodiversity of an area starting from the smallest bacteria to large faunas. In the KT project therefore is chosen to focus on the 'keystone' species. This refers to species which have a disproportionately large effect on its environment (natural and human). According to the ESIA (RHDHV ToR ESIA, 2017) these 'keystone' species must meet the following criteria:

- Play a critical role in an ecological community
- Easy to detect, study and monitor
- Availability of data, study methods, and expertise
- Economically important

#### 4.4. Ecosystem services provided by the system

Before starting with the design phase, the BwN approach prescribes a better understanding of the natural system. Together with findings of the previous sections, the following ecosystem services are identified. The ecosystem services are divided into four categories already described in section 2.4. [Building with Nature guidelines and philosophy](#). These services provided by nature will be incorporated in the design creating benefits for nature and society.

Provisioning services:

- Food (fish, shrimp, crab, shellfish, coconut, and organic matter by [mangroves](#))
- Habitat of marine fish larva (anadromous fish between [mangrove](#) roots)
- Habitat of local and migrating birds ([mangrove](#) trees)
- Transportation function of the river (ships transport goods and people)
- Fresh water (for drinking, washing, irrigation, and [mangroves](#) remove nutrients)
- Fuel wood ([mangroves](#) provide timber and charcoal for cooking)
- Construction material (for houses and ships)
- Agricultural area (rice, palm oil)

## Regulating services:

- Coastal protection (by **mangroves** and mudflats capturing sand)
- Sediment transport (rivers, along the coast)
- Disease regulation (biodiversity, river as waste regulator, medicinal plants)
- Climate regulation (biodiversity)
- Water regulation (banks and mangroves filtering and clearing the water + drainage of rainwater entering the system)
- Pollination (by biodiversity)
- Carbon sequestration (**mangroves** play a key role in the regulation of atmospheric carbon dioxide levels, they rank among the most carbon rich forests in the world Donato et al. 2011 (Winterwerp et al., 2013))

## Cultural services:

- Cultural heritage (generations of people living along rivers)
- Recreation (swimming, trekking)
- Tourism (small eco-tourism resort at KT)
- Aesthetic value (nature, rivers, mudflats and **mangroves**)
- Sense of place (value and enjoyment for humans, biodiversity, important bird area)



Figure 39 Livelihood of communities around Kuala Tanjung (RHDHV ToR ESIA, 2017)

With the above ecosystem services identified and a clear view on the system (physical, socio-economical and governance), a study into potential BwN solutions will be done in the next sections.

### 4.5. Potential BwN solutions

From a literature study on applied BwN solutions all over the world, it is concluded that the following BwN solutions are potentially applicable for KT:

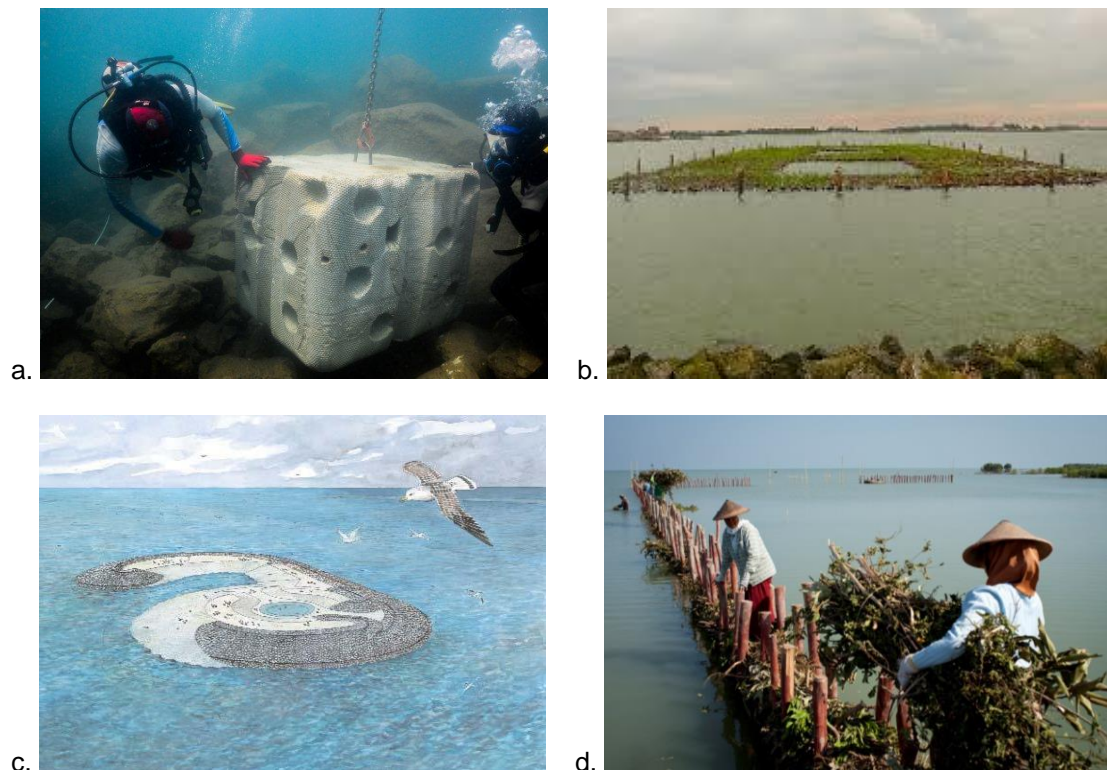


Figure 40a: E-concrete as revetment of breakwater (*both designs in section 4.6*), b: floating marsh in front of breakwater (*both designs in section 4.6*), c: bird island using dredged material (*both designs in section 4.6*), d: permeable dams to attenuate waves (*onshore design in section 4.6*). (<https://www.econcretetech.com>; BwN guidelines; <https://www.deltares.nl>)

### 4.6. Alternatives for port development

As described in the previous chapter, the current port activities at the PoKT make use of long jetties to reach deep water. Constructing a jetty avoids the need of dredging which can be complicated in a muddy environment. Disadvantages of using a jetty are the distance between unloading/storing the cargo and the depth for constructing a breakwater. In developing the PoKT a choice has to be made between developing offshore berths or close to shore berths by dredging.



Figure 41 Jetties present at Kuala Tanjung (drone image 01-02-2017 PoR)

A jetty is an open structure where water can flow through that projects from the land out into the water (Figure 41). If the tip of the jetty reaches sufficient deep water for the ship to sail, (almost) no dredging is needed. In most cases berths at jetties are not protected from incoming waves by a breakwater, because constructing a breakwater at large depth requires a lot of reclamation fill which is expensive. Therefore, exposed jetties are not suitable for handling ships which cannot be served when waves are too high (like container ships). On the other hand, an advantage is that water with sediments can flow underneath the structure so impact at the coastal system is minimised. In general, constructing a jetty is also less expensive than dredging an area close to shore. Another way of working offshore without land reclamation, is constructing a deck (terminal) on piles (Figure 42). This is more expensive than creating a long jetty connected to land, but it has the same advantages of a jetty plus the advantage of having a storage area directly behind the berths. When reclamation fill is scarce (and expensive) this solution for offshore development is preferred.



Figure 42 New Priok development Port of Tanjung Priok, Jakarta (<https://www.dutchwatersector.com>)

Berths close to shore at a terminal with quay are necessary for the efficient handling of all non-bulk cargo. Marginal quays are also often used for large dry bulk terminals when heavy gantry cranes must be able to reach the full length of the ship. (Ligteringen, Velsink, 2017) An advantage of onshore terminals is the potential to have efficient connections with the hinterland (Figure 43). To make the berths accessible for large ships, dredging an approach channel and basin is needed. The costs of constructing a breakwater to protect the ships at the berths against swell waves are relatively low (compared to offshore berths) because of the shallow area. In all cases this onshore development with breakwater is more expensive than constructing jetties with exposed berths, but on the long-term CAPEX or more downtime (resulting in less revenues) has to be made.



Figure 43 Euromax Container terminal Rotterdam (<https://www.portofrotterdam.com>)



Another option is to construct a jetty which is protected by an offshore detached breakwater similar to the one constructed at the port of Pecém (Figure 44). In this case the breakwater is constructed at deep water which makes it expensive, but the impact on the coastal system is limited since longshore sediment transport is not blocked. A disadvantage of this solution is that the offshore land reclamation requires a source of suitable sediment. In addition, the storage area is limited and only connected with the hinterland by one road.



Figure 44 Port of Pecém (Brazil) offshore terminal (<http://www.seatrade-maritime.com/news/europe/port-of-rotterdam-authority-to-invest-in-the-port-of-pecem-brazil.html>)

The discussion about the financial aspects and results of a more expensive protected port by breakwaters or a port with only exposed berths is a study on its own (Figure 45). The downtime of exposed berths is larger, but a jetty is cheaper than constructing a breakwater and dredging a basin. Dredging a deep basin for ships will have the risk of trapping mud resulting in high maintenance dredging.

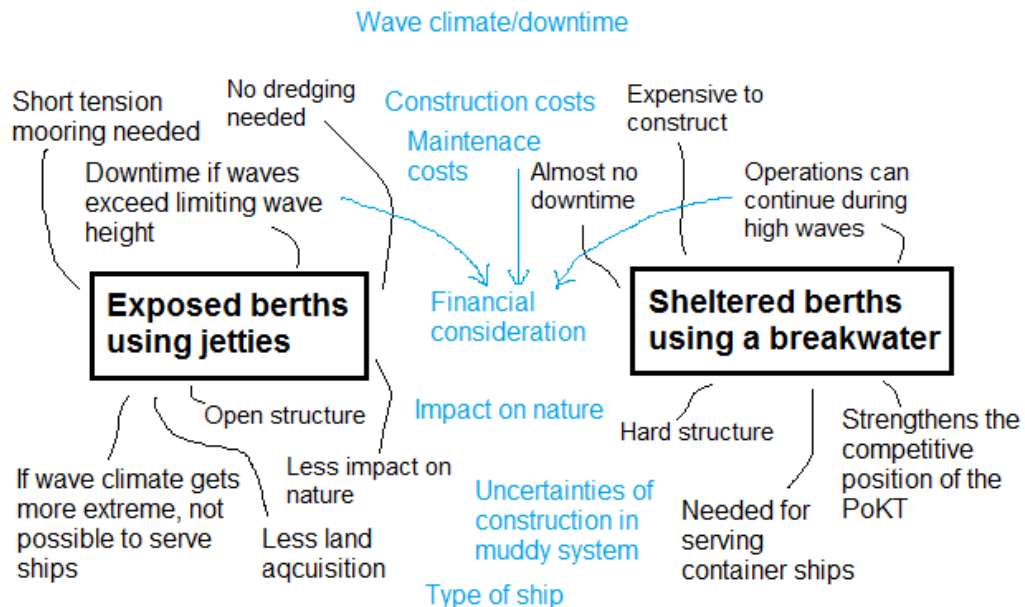


Figure 45 Consideration onshore versus offshore. Downtime and construction/maintenance costs lead to financial consideration (author)

### 4.6.1 Onshore versus offshore port development for the PoKT

Mainly the [wave conditions](#) and the [types of ships](#) determine if a breakwater is needed and economically feasible. The significant wave height at KT as described in section 5.1.5 [Wave energy](#) exceeds 1.5 m for only 0.15% of the time (about 1 day a year). Dry bulk, tankers and some general cargo ships cannot be served if wave heights exceed 1.5 m (Table 2). Since only these types of ships are expected in the first three phases of the PoKT port development, no breakwater is needed. The downtime for these types of ships can be limited by using 'short tension' mooring. In case of offshore development, a deck on piles is preferred since potential sources for reclamation fill are not identified yet. A deck on piles create a stable platform which can be used without waiting for settlement or ground improvement measures.

In the long term (phase 4 of current master plan) the goal is to serve breakbulk and container ships which cannot be served if significant wave heights exceed 0.5 m (Table 2). Given the wave climate at KT it is decided that a breakwater is needed to serve these types of ships. In this way the ambition to build a world-class container port (government of Indonesia) is pursued. The main goals of realising the PoKT are creating added value for Indonesia (especially Sumatra) and creating jobs for the people of the Batubara region. The challenge is to realise these goals in harmony with nature. The present ecosystem services need to be preserved and/or can be used for realising the goals.

In this challenge a trade-off has to be made between avoiding any impact on area (by designing around the system) or accepting certain impact for the positive effects on different scales (regional and national). Because of this, one conservative solution is made, which fits in the current master plan with minor changes in port design and planning, and a more 'out-of-the-box' solution is made. The latter design avoids all social and environmental impact and is likely to be too expensive to realise.

There are two main reasons for applying permeable dams and mangroves in case of an onshore development:

1. From Chapter 3 [Evaluation of the current master plan of Kuala Tanjung](#), it was identified that the breakwater formed a major part of the CAPEX and therefore seen as an opportunity for improvement in the current master plan. Wave climate at KT is moderate, but the goal of the Indonesian Government is to "create a world-class container hub, implying 24/7 operations".
2. From section 4.4. [Ecosystem services provided by the system](#) and 4.5. [Potential BwN solutions](#), it was identified that mangroves offer lots of key ecosystem services, whereof the most important one is: stabilize the coast and attenuate waves.

Reference has already been made to the ports of Tanjung Priok (Jakarta), the port of Rotterdam and the port of Pecém (Brazil). In [Appendix D](#) other ports located at the strait of Malacca are considered to get a better understanding of their location and orientation. In the next two sections multi-objective landscape designs are made on a conceptual level.

### 4.6.2 The onshore alternative

This design starts with expanding the present mangrove forests by creating the right conditions for (replanted) mangroves to grow in seaward direction at the future location of the breakwaters. This is done by raising the bed level at the mudflats with dredged soil and creating the right conditions for mangroves to establish. In this way the ecosystem services are created and used in the design. Diverting the Bah Bolon river is only needed when more area is needed for the breakbulk and container terminal. In this way large CAPEX are postponed.

#### Phasing

In the second phase (after the MPT jetty is constructed) a new jetty is constructed, since the wave climate is acceptable for the types of ships (dry and liquid bulk) expected in the first years. A powerplant, refinery and eventually a cement plant are expected in this first phase. Co-operating and using the same jetty results in a higher utility rate of the jetty and lower costs. The jetty has different type of berths to serve the different expected ships.

Parallel to this, a sandy/muddy breakwater is constructed on the SE side of the two river branches at Kuala Indah village (fisherman village), so river diversion and resettlement is postponed. On the north-western side of this breakwater there is now space for mangrove development and/or floating marshes. The first terminal (eventually a power plant) can be built in a non-residential area south-east from Pt. Inalum with some land reclamation to avoid resettlement (yellow, Figure 46).

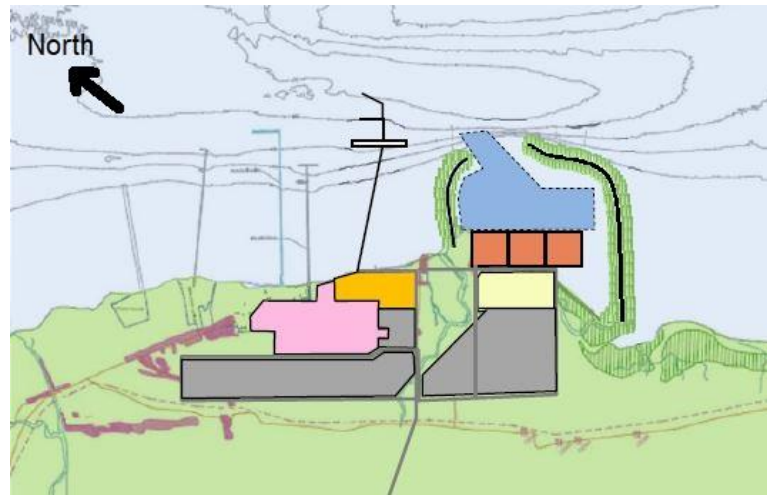


Figure 46 Alternative plan after meeting 7-12-2017 (author)

In the third phase a new industrial plot and breakbulk/container terminals can be created at the location of the headland protected by the north-western breakwater. Dredging is needed to provide sufficient depth at these terminals. In Figure 46 these terminals are shown as three orange blocks partially on land but also at sea. Because of the initial width of the breakwater first the middle orange block will be developed. The part which forms the border between land and water is constructed as a deck on piles like is done for the New Priok Development in Jakarta (Figure 42). In this phase extension is possible in the grey area of Figure 46.

A new village with apartment buildings and shops will be developed south from Suka Ramai village. From this moment the residents of Kuala Indah who are willing to move to a proper and safe apartment building can start moving. The residents who want to stay can stay at Kuala Indah village with the river branch still flowing along the village.

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[!] Note the difference with the current master plan: the original phase 2 and 3 are now split so the Bah Bolon river can flow in between, and resettlement is not needed.

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The dredged material can be used to initiate the second breakwater on the SE side of the headland, just north of the two river branches (Mati and Kuba/Gambus Laut river) the present mangroves forest will be stimulated to grow in seaward direction. This is done by elevating the bed level of a stretch in seaward direction up to +1.50 mCD<sup>10</sup> and installing brushwood dams to retain the soft soil and the growing pioneer mangrove species (*Avicennia alba* and *Avicennia officinalis*) already present in the system. This will be executed in steps up to the -10 mCD<sup>11</sup> creating on both sides a slope of 1:125<sup>12</sup> to the original bed level. The mangroves that need to be cut for the construction of the terminals, can be replanted in between the permeable constructions at the right place. This process is executed parallel to the third phase. A nature-based breakwater is formed, far away from the first port development, capturing sediments from the Bah Bolon river

<sup>10</sup> Assumed dimension. Feasibility study in chapter 5 turned out: elevation up to +1,60 mCD needed.

<sup>11</sup> Assumed dimension. Feasibility study in chapter 5 turned out: technically feasible up to -5 mCD.

<sup>12</sup> Assumed dimension. Feasibility study in chapter 5 turned out: a slope of 1:400 needed.

and therefore growing in time. After one year, pioneer species can already be 1 meter high and function as a wave dissipater. (Lee, Tan, and Havanond, 1996)

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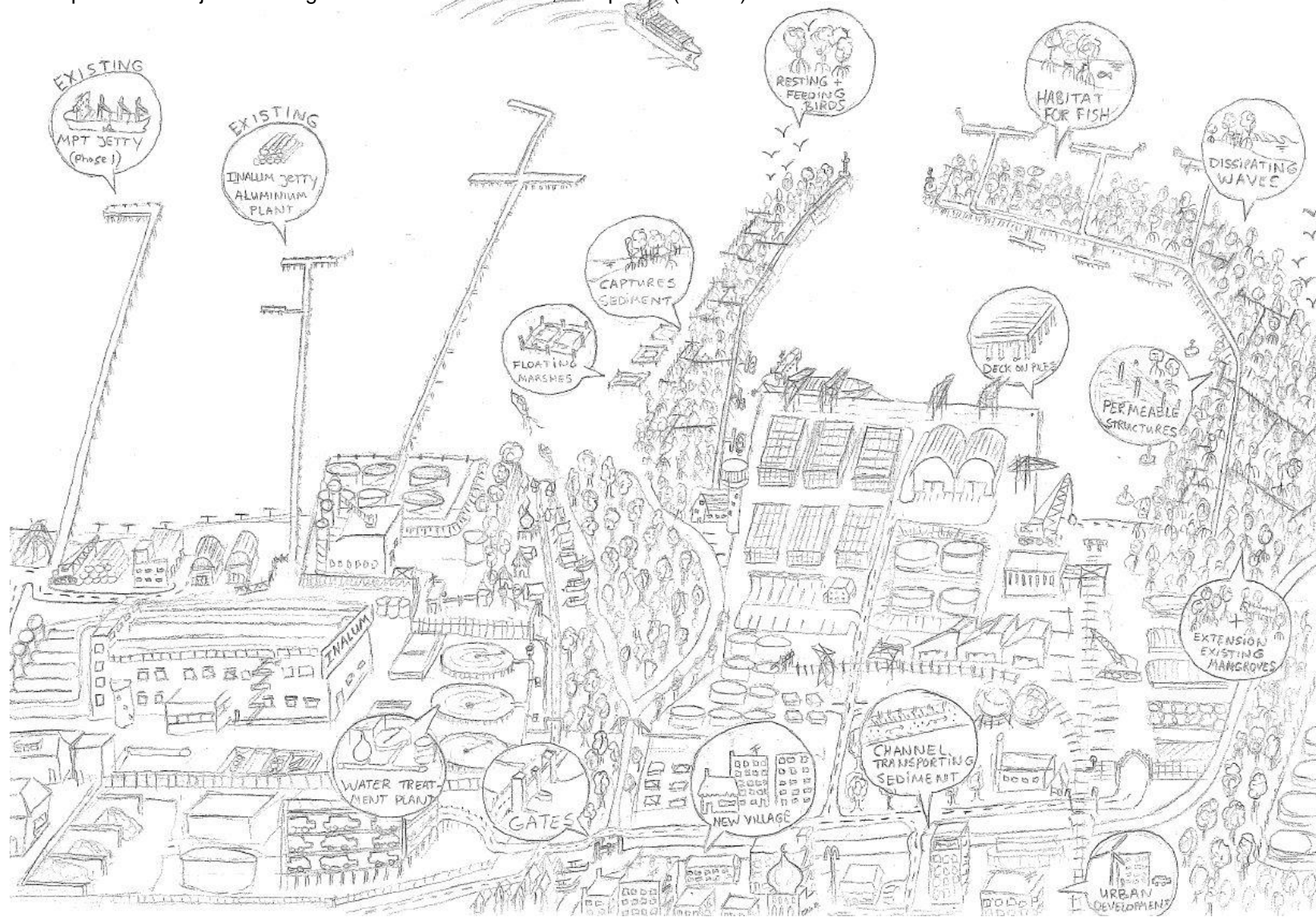
[!] Note the difference with the current master plan: the dredged material (silty sand) is re-used to create the right conditions for mangroves to grow.

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In the fourth phase, when the new mangroves are already grown and catching sediments from the river, associated industries can settle on the SE (right) side of the second phase. Break bulk and container terminals require some land reclamations or a deck on piles and deepening of the basin. In this phase the main branch of the Bah Bolon river will be diverted around the industrial complex to the river branch at the south-east in a BwN way, supplying sediment to the location where erosion is expected due to an obstruction of the littoral drift of sediments. The river branches flowing along Kuala Indah will stay at its location, but the inflow of these branches is regulated with gates/valves. In case Kuala Indah is completely resettled this is not necessary which makes this design adaptive. The river diversion enables new area to be developed as industrial area.

In the last phase (after approximately 5-10 years of operation) the extension of the port may reach the shallow part created by the new mangrove forest. The deep basin can be extended in SE direction by replacing the, in the meantime fully grown mangroves to the SE side of the mangrove stretch in between the present mangroves. The inner slope of the mangrove breakwater will be steepened. See next page for the multi-objective conceptual landscape design.

Figure 47 Conceptual multi-objective design of the onshore solution, final phase (author)



In first stages of the mangrove breakwater it is still possible to have a mild slope on both sides of the stretch because the port development activities are still away from this breakwater (Figure 48). The inner slope of the created natural breakwater can be steepened at a later stage by using geo-tubes at the toe of the breakwater and choosing the right revetment (Figure 49). The outer slope of the breakwater can remain the same because on this side no shipping is expected.

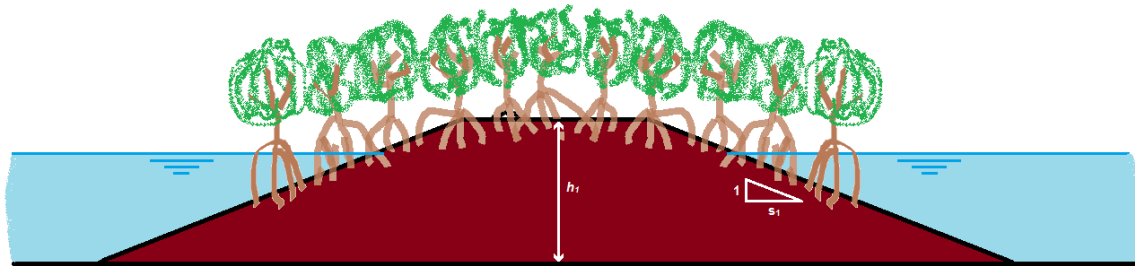


Figure 48 Conceptual sketch of the cross-section of a mangrove breakwater in the first phase (on both sides mild slope)  $s_1 \approx 1:400$  (author)

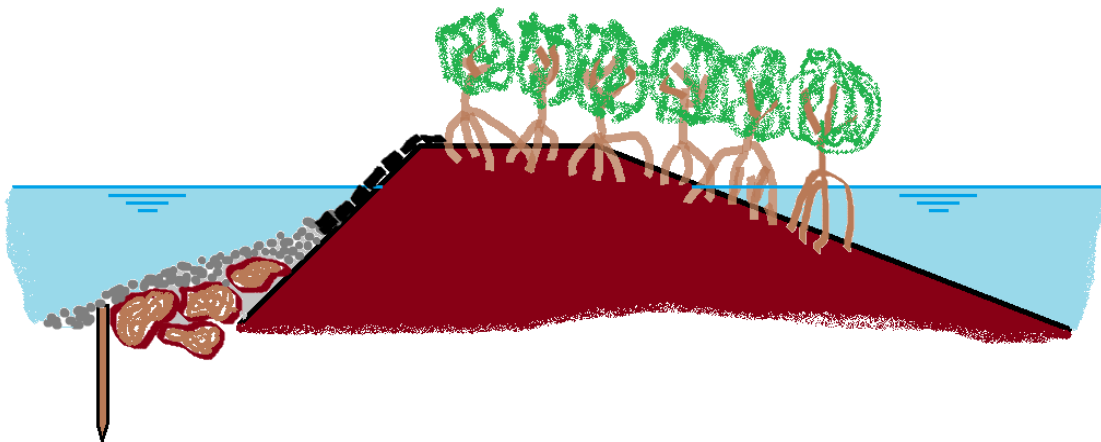


Figure 49 Conceptual sketch of the cross-section of a mangrove breakwater final phase with basin 'left' and mild outer slope 'right' (author)

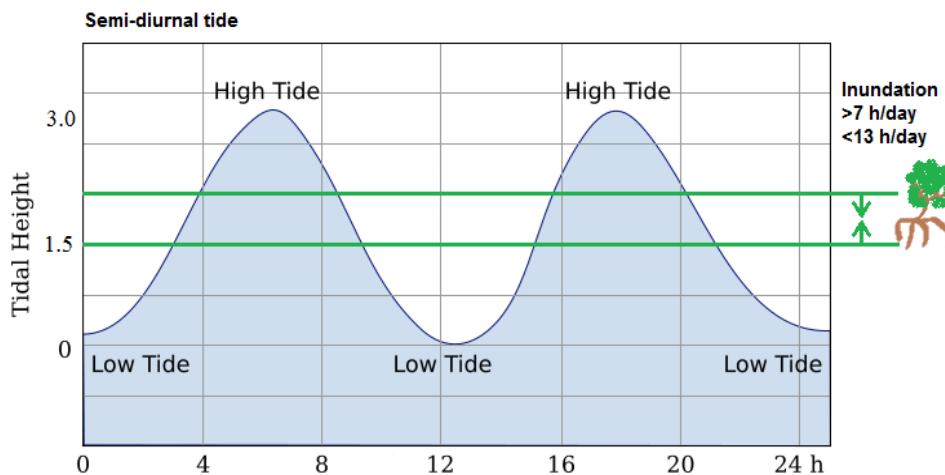


Figure 50 Semi-diurnal tide at Kuala Tanjung indicating (green lines) the needed elevation for mangroves to grow (author adapted from <http://www.sailingissues.com/navcourse6.html>)

In the next chapter the mangrove breakwater will be elaborated upon. If the Bah Bolon river has to be diverted, this can be done by using natural processes. When the difference in elevation between the starting point of the canal and the sea level is large enough to create a fast-flowing narrow channel, the channel is likely to widen automatically by erosion of the banks. The channel will transport the sediments to the location at the coast where erosion is expected (downdrift side of the port).

## PROS:

- **Natural processes are used** in the design to let the mangrove breakwater naturally 'grow' (e.g. current and sediment supply by river).
- **Mangroves are stimulated** in the design creating the ecosystem services provided by mangroves.
- **Until last phase, free outflow of the two main rivers** by splitting the land reclamation between phase 2 and phase 3 into two sections thereby allowing for a free outflow of the main river in between;
  - (Ground)water equilibrium of the river delta is not disturbed as river system remains intact. (RHDHV, 2017e)
  - Potential flooding and upstream river issues (due to increased or decreased flow of the diverted river) are avoided as the rivers remain intact.
  - River bounded shipping traffic can continue.
- **Fishing grounds can still be reached** by local vessels whilst sailing in between the port development.
- **A small boat harbour is created**, providing safe sheltered berths for small crafts such as pilot boats, support vessels and tugs. (RHDHV, 2017e)
- **Connection to the hinterland** by roads, trail is efficient since the terminals are located onshore. (RHDHV, 2017e)
- **Terminals are all located close to each other** providing the possibilities of shared utilities and cooperation.
- **Very sheltered berths** for 24/7 container terminal operations created by the two breakwaters. (RHDHV, 2017e)
- **The CAPEX for the breakwater are likely to be lower** since dredged material is reused and breakwater is growing 'naturally' by trapping sediment (permeable dams).
- **Dredged material (mud) can be reused** for the nourishing of the breakwater creating a win-win solution.
- **Wave damping by mangroves** and less reflection of waves inside the basin compared to a hard breakwater.
- **The development is sustainable regarding climate change** since the mangroves form a sustainable barrier which grows with (relative) sea level rise.
- **The development is adaptive**: based on the still flexible business case and ongoing negotiations with potential anchor tenants, having a solution with a higher degree of flexibility on how much area to reclaim (without reducing the length of the berths) will allow the project to follow market demand more closely (and thus achieve a more optimal balance between costs and revenues). (RHDHV, 2017e)

## CONS:

- **There is still an impact on the settlements** (villages) around the river, although less drastic than in the original plan where the entire river system had to be diverted.
- **The connection between phase 2 and phase 3 is limited** as the Bah Bolon river is still located in between. This limits the sharing of utilities and cargo flow between these areas. If needed a connection between phase 2 and phase 3 could be created by means of a bridge or elevated road to connect the two areas.
- **The growing of mangroves takes time**, so the initial location of the breakwater is already partly fixed independent of the future scenario.
- **Erosion on the downdrift** side of the port is expected, since the mangroves will trap sediment.
- **The mangrove-based protection is still in its infancy**, since pilot projects at Java are still going on. Tests at KT should be carried out to determine whether mangrove stimulation works at KT.
- **In deep water large amount of nourishment is needed** to create a shallow stretch with mild slopes and potential sources for the reclamation have not yet been identified (RHDHV, 2017d)

### 4.6.3 The offshore alternative

To avoid river diversion in all phases and to limit the impact on the ecology of the estuary, a second design is considered which mainly consists of detached islands. Since a potential source for reclamation is not identified yet, a deck on piles as done for the New Priok Development in Jakarta (Figure 42) is proposed. In addition, this solution prevents soil improvement measures which are needed for constructing close to shore land reclamations (and onshore land elevation).

#### Phasing

In the second phase (after the MPT jetty) an island at the shallow area in front of Kuala Indah village is made to create area for the first terminal. Since land prices are expected to be lower than offshore development some storage area will be located at the mainland (onshore). This first island will be connected to the shore by two bridges, allowing the longshore current to transport sediment and allowing the small fisherman boats to go to sea.

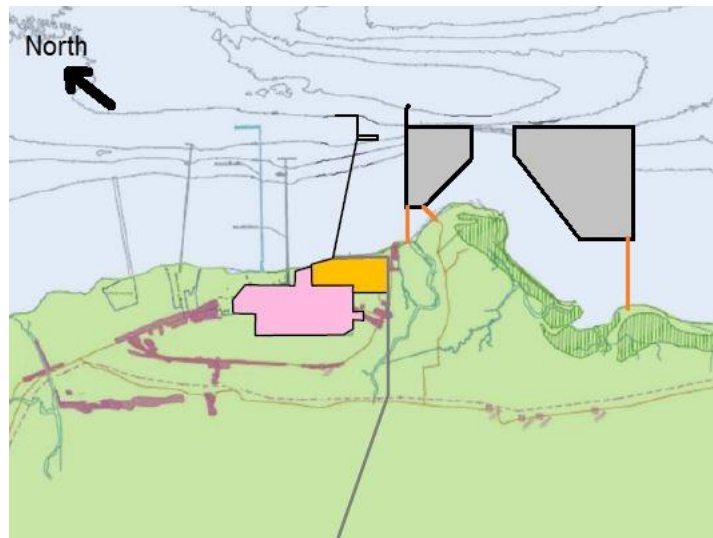


Figure 51 The offshore alternative (author)

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[!] Note the difference with the current master plan: no resettlement and almost no land acquisition is needed since onshore development is limited

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In the third phase a 'hard' breakwater (with E-concrete blocks) will be constructed on the seaside of the island until the -20 mCD depth contour. This will protect the berths (breakbulk/container ships) from waves coming from the NNW. In this hard breakwater E-concrete revetment is used to stimulate the growth of macro-algae and macro-fauna.

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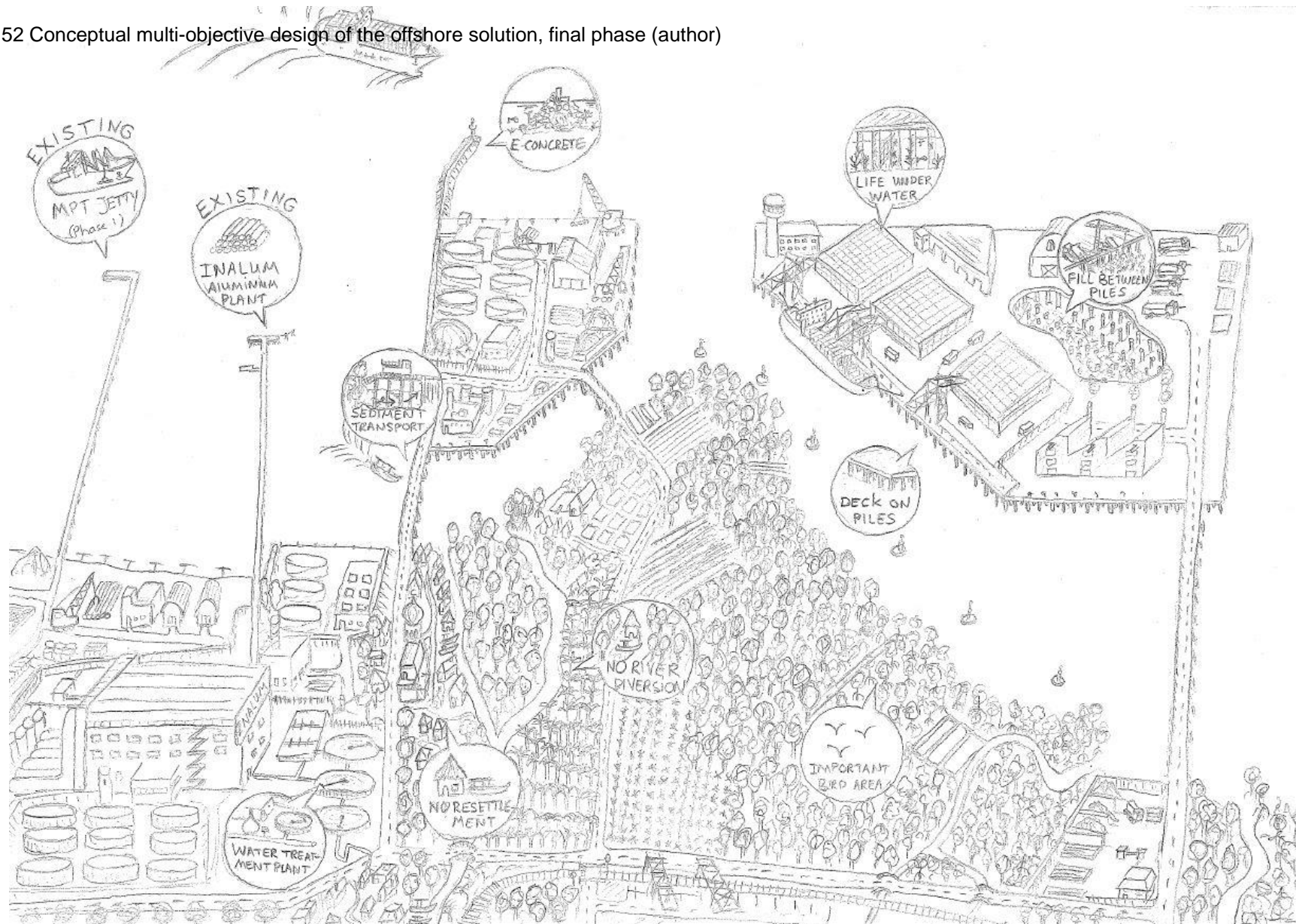
[!] Note the difference with the current master plan: only a small hard breakwater is needed on the north-western side

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The fourth phase will be initiated when all the created area of phase 1 is fully assigned to industries. A second island on the SE side of the first island will be created which is not attached to the first island. Ships can enter a protected basin in the lee of the first island and second island. In between the piles some nourishment is still needed to prevent the waves from penetrating underneath the deck towards the protected basin. Besides nourishing, placing metal grids will stimulate the growth of mussels and shells underneath the deck. See next page for the multi-objective conceptual landscape design.



Figure 52 Conceptual multi-objective design of the offshore solution, final phase (author)



### Offshore design: (partially filled) deck on piles

As described before, no offshore land reclamations, as has been done for the extension of the port of Rotterdam (Figure 43), are considered. The main reason for this is the instability of the mudflats, which are not suitable as a basis for the reclamations without removing the large muddy top layer. In addition, major soil improvement measures are needed before construction on the land reclamation is possible. In between the piles some parts must be filled up to create shelter on the lee side of the islands. This nourishment will also prevent currents flowing underneath the deck (with floating waste) damaging the piles.

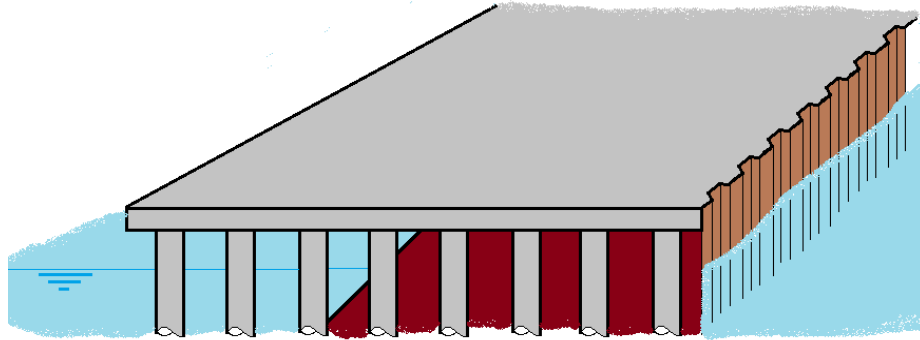


Figure 53 Conceptual sketch of the offshore solution, deck on piles (author)

#### PROS:

- A water zone of several hundreds of meters (~200m to ~600m) is created between the partially filled deck on piles and the shore to **limit the negative impact on the coastline (protected) areas**. (RHDHV, 2017e)
- The body of water around the islands allow **longshore sediment transport to flow freely**.
- **Free outflow of the two main rivers** in the large water area between the coastline and reclamation areas
  - (Ground)water equilibrium of the river delta is not disturbed as river system remains intact. (RHDHV, 2017e)
  - Potential flooding and upstream river issues (due to increased or decreased flow of the diverted river) are avoided as the rivers remain intact.
  - River bounded shipping traffic can continue.
- **Fishing grounds can still be reached** by local vessels whilst sailing in between the two islands.
- **There is almost no impact on settlements** (villages) around the river and the coastline, however, much less than in the original plan.
- **A small boat harbour is created in both phases**, providing safe berths for small crafts such as pilot boats, support vessels and tugs. (RHDHV, 2017e)
- Very sheltered container berths at lee side of second island.
- **More sheltered berths for smaller vessels** such as coal barges, resulting in reduced downtime.

#### CONS:

- **The connection between the offshore islands** and the shore is facilitated by multiple elevated roads & railways, bridges (or even tunnels). The exact number of connections with the hinterland can be adjusted based on throughput and traffic flow requirements;
- Filling up some areas in between the piles more towards the south-east results in **large reclamation volumes**.
- The connection between the islands is limited, as the port basin is created in between. This **limits the sharing of utilities and cargo flow** between these areas.
- **Potential (offshore and onshore) sources for the reclamation** have not yet been identified. (RHDHV, 2017d)
- **Sediment transported by the Bah Bolon river may clog up at the river mouth**, where the islands may block the free outflow.
- **Wave energy clogging up underneath the concrete deck**, resulting in extreme forces acting on the concrete.

## 4.7. Evaluate alternatives

After identifying the ecosystem services provided by the natural system, and a literature study on applied BwN solutions all over the world, two alternatives are proposed. An onshore alternative including mangrove stimulation and an offshore alternative limiting the impact on the ecosystem.

As mentioned in 4.6.1 [Onshore versus offshore port development for the PoKT](#), the financial consideration of developing offshore or close to shore is a study on its own. Onshore land prices are expected to be less than the costs for offshore land reclamation, but onshore terminals require more dredging to make the berths accessible for ships. Besides, close to shore it is financially more feasible to construct a breakwater compared to protected jetties reaching all the way to deep water. The need for breakwaters is determined by the acceptance of downtime (when ships cannot be served). Since the ambition of the Indonesian government is to create a world-class container port at KT in both alternatives sheltered berths for break bulk and container terminals are included.

The two alternatives are judged on the following functional criteria (also generally used by RHDHV) and are compared with the port layout of the current master plan:

- **Flexibility in implementation:** *refers to the level of flexibility in which berths and reclamations can be developed independently from each other.*

Both alternatives are more flexible in implementation than the current master plan, since no involuntary resettlement is needed and the original phase 2 (power plant, steel industry and cement) and phase 3 (refinery, heavy industries and break bulk) are split up avoiding unnecessary negative impact if the throughput of phase 3 is less than expected.

The onshore solution is flexible in implementation since this alternative consists of several phases considering the future uncertainties, but this alternative is not flexible regarding the SE breakwater, which is already 'fixed' at a certain location.

The offshore solution is flexible because the port development is not dependent of any land acquisition and the initial size of the island can be reduced if throughput is lower than expected, but the connection between the islands is limited, as the port basin is created in between.

- **Shared utilities:** *refers to how easy it is for one utility-centre (water, electricity etc.) to serve different development phases of the port.*

Both alternatives have limited sharing of utilities compared to the current master plan, where all planned terminals and industries are located close to each other.

The onshore alternative offers more possibilities for sharing utilities than the offshore alternative where the connection between the two island is limited, as the port basin is created in between. To connect the different terminals and industries in the onshore alternative, bridged for pipelines/cables are needed to connect phase 2 and phase 3.

- **Ease of vessel manoeuvring:** *refers to the ease of vessel entering, berthing and unberthing in each port alternative layout.*

The ease of vessel manoeuvring for the onshore solution is almost the same as the current master plan, but the onshore alternative has the advantages that waves are damped by the permeable mangrove system. Hard breakwaters will result in reflection and resonance of agitated waves inside the port basin.

The ease of vessel berthing and unberthing is better for offshore berths without a port entrance provided that the waves are not too high.

- **Berth shelter and downtime:** *refers to whether and how much berths are protected from waves and thereby reflecting the potential level of downtime (especially for smaller vessels, barges and container vessels) of an alternative port layout.*

For the first berths to be developed, both alternatives will have the same level of downtime since the first berths will not be protected from waves.

In the final phase the offshore alternative will have more unsheltered berths and will therefore have a higher level of downtime than the onshore solution, but the offshore alternative will also have enough sheltered berths.

- **Impact on (flushing of) protected areas:** *refers to whether the protected areas onshore (e.g. mangroves and bird nesting areas) are impacted and/or whether there is enough flushing of these areas and thereby maintaining a healthy balance of sedimentation and erosion to support these protected areas.*

Both alternatives have less impact on the protected areas than the current master plan, but the offshore solution will have the least impact on the protected areas.

- **Sedimentation at berths:** *rivers transporting sediment to the coast, combined with tidal effects, might result in local sedimentation. This criterion indicates whether this is expected at the berths within the port area and in turn requiring regular maintenance dredging.*

The offshore alternative is expected to have the most sedimentation at the berths since the Bah Bolon river is still debouching on the downdrift side of the basin. The basin of the current master plan and the onshore alternative is protected by breakwaters, but crosscurrents (tidal currents) may result in local sedimentation. For the onshore alternative, the dredged material can be used to nourish the mangrove system.

- **Negative social impact (negative impact on livelihood of residents):** *indicates the negative social impact at (or nearby) the coastal zone due to the construction of a port layout.*

The offshore alternative will have the least negative social impact compared to the onshore alternative, which requires some land acquisition at areas which are currently used for agricultural purposes. The current master plan requires even more land acquisition and resettlement resulting in large negative social impact.

- **Impact on river flow (land drainage):** *refers to whether a port layout would affect the natural outflow of the river and as such the natural drainage capacity and ground water balance of the area.*

The current master plan already requires river diversion in phase two affecting the natural outflow of the river and affecting the water level upstream. The onshore alternative only requires river diversion at the final phase when the area is needed for further development of the container terminal. In this case the river will be regulated by gates allowing some discharge to the river branch at Kuala Indah.

The offshore alternative prevents river diversion, but sediment transport by the Bah Bolon river may clog up at the river mouth, where the islands may block the free outflow

- **Hinterland connections:** *refers to the ease of transporting between the port and hinterland, as reflected by the number and use of shore connections (bridges).*

Compared to the current master plan the onshore solution will have the same possibilities of connection with the hinterland, except for the extra bridges across the Bah Bolon river.

For the offshore alternative it is clearly more difficult to create an efficient connection to the hinterland.

- **Terminal efficiency:** *whether the cargo can be stored in the direct vicinity of the quays or additional (internal) transport to/from onshore storage areas is needed.*

The onshore alternative will have the largest terminal efficiency since the storage areas are directly located behind quays. For the offshore alternative some storage area is located at the mainland requiring transport to/from the berths to the storage areas across bridges.

In general, the terminal efficiency of the onshore alternative is the same as the port layout of the current master plan.

- **BwN possibilities (win-win scenarios):** indicates the possibility to apply the BwN philosophy in the port layout and create a win-win scenario.

In the current master plan only mitigation and compensation measures were proposed to deal with the negative environmental and social impact.

The offshore alternative offers little opportunities for applying the BwN philosophy: using E-concrete blocks (stimulating the growth macro-algae and macro-fauna), a metal grid (stimulating the growth of mussels and shells) or installing floating marshes. The main idea of this alternative is avoiding impact on nature.

The onshore alternative offers the most opportunities for applying the BwN philosophy. Besides the above-mentioned BwN solutions for the offshore alternative, the onshore alternative offers: reusing the dredged material for mangrove stimulation, using the mangroves to attenuate waves (and provide its ecosystem services), and eventually creating a bird island on the shoal area with the dredged material. In the original master plan the dredged material is not used at all, missing a lot of BwN opportunities (if the dredged material is used for the construction of the breakwater a new business case is formed).

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Looking at the criteria above, both alternatives represent an improvement of the current master plan. From a BwN point of view, the onshore alternative offers more opportunities to apply the BwN philosophy, while the offshore alternative 'avoids' nature instead of 'building with' nature. Therefore, from this evaluation it is chosen to elaborate on the onshore alternative and to determine the feasibility of the proposed BwN aspects. Discussions with port experts confirmed this choice regarding the functional requirements of the port.

#### 4.8. Conclusion: selecting an alternative

The potential impact of implementing the BwN philosophy in the 'traditional' master plan of the PoKT could be large since this project is still in the initiation phase. Nevertheless, there are already some limitations in applying the BwN philosophy. The most important one is the project location, which is already chosen for strategic and financial reasons. Compared to other ports at the strait of Malacca, the PoKT does not have a large inland waterway (Medan), natural protection from waves by an island (Kuala Lumpur) or a good existing infrastructural network and sandy environment (Singapore).

Aside from this, there are still enough degrees of freedom to change the master plan and incorporate the BwN philosophy. A BwN solution attempts to meet society's needs for infrastructural functionality, while creating room for nature development at the same time. Although the current master plan forces to look from a project point of view, the BwN approach requires to look at the natural system first to identify the present ecosystem services and possibilities to use or create new ecosystem services. After a literature study of applied BwN solutions all over the world, several BwN solutions for the PoKT development were identified.

The current port activities at KT are using jetties to reach deep water, but these berths are all exposed to waves resulting in downtime. Onshore port development requires dredging, but the terminal efficiency is higher, and breakwaters can be constructed at relative shallow locations. It is concluded that breakwaters are needed to create a world-class container terminal, which is a goal of the Indonesian government. On the short-term, offshore development (exposed jetties) is accepted because the type of ships expected in the first two phases can handle higher wave conditions than container ships (last phase). Two alternatives, both with sheltered berths for final phase, are proposed: the onshore and the offshore alternative. In the onshore alternative the focus lies on the stimulation and use of the ecosystem services provided by mangroves. The offshore alternative limits the impact on the ecology of the estuary. The latter alternative deviates the most from the current master plan, while the onshore alternative only requires several modifications in port planning and design.

After evaluation of the alternatives, together with experts involved in the KT project (Figure 68 in [Appendix D](#)), it is concluded that the onshore alternative is more realistic from a functional point of view, while still offering opportunities for applying the BwN philosophy. In the current natural

system of KT the mangroves offer various important ecosystem services. In addition, it is concluded that the breakwaters proposed by the current master plan form a large part of the CAPEX. Consequently, a solution is proposed where mangroves are integrated in the design to attenuate waves and enhance nature at the same time. This alternative can even lead to a cost reduction in the long term.

The offshore alternative 'avoids' nature instead of 'building with' nature but is still a good alternative to consider. The main advantage of developing the port onshore is the possibility to create a port-industrial complex where utilities can be easily shared. The next chapter elaborates on the selected alternative, and a preliminary design of the mangrove breakwater is made. A preliminary feasibility study will determine to what extent the mangroves can be implemented in the breakwater design.

# 5 The onshore alternative: feasibility of mangrove breakwater

In this chapter the selected onshore alternative is studied in further detail to create a mangrove-based protection to reduce breakwater costs and enhance nature. It is checked how realistic the mangrove-based breakwater is by executing a preliminary technical feasibility study. In this feasibility study the necessary conditions for mangroves are identified. In addition it is checked how these conditions can be created at the location of the breakwaters. The type of mangrove (species), the time of the year (monsoon or not) and the hydrodynamic conditions are key factors in determining whether mangroves can grow. If the concept is feasible, more wave damping is expected (compared to hard structures), a new business case is created by re-using the dredged material and nature is enhanced at the same time.

After this study, some main dimensions of the mangrove-based breakwater are determined. Together with the other adaptations of the current master plan the zoning plan will be described in more detail. The question to be answered in this chapter is: which considerations are required in the current master plan in order to implement the proposed Building with Nature solution and what are the implementation risks?

## 5.1. Conditions for the (natural) establishment of mangroves

A literature study of mangrove conservation and restoration programs results in an advice for implementing mangroves as part of the breakwater. The habitat requirements include conditions for natural establishment (expansion of existing mangroves) as well as conditions for planting and growing of juvenile mangrove trees. Every habitat requirement will be treated in a separate subsection describing whether the condition is naturally present or can be engineered at KT. In addition, recommendations are given if more precise information is needed (mangrove expertise). The necessary conditions for mangrove establishment are obtained from:

- occurrence and health of species present at the site
- available literature

After this a balance between natural establishment and planting of mangroves is described for the mangrove-based breakwater. General recommendation: data collection, measurements (field work) and computational modelling are needed to confirm the findings.

### 5.1.1 Climate

Mangroves can only grow in a tropical or subtropical climate. (Ecoshape Demak, 2018)

✓ The islands of Indonesia have tropical climates which are known for their high temperatures year-round and for their large amount of year-round rain. At KT (equatorial climate) there are already several species of mangroves present (see Figure 9). An exploratory study of mangrove species at the project area is already executed and pioneer species like *Avicennia* spp. are identified in the system.

### 5.1.2 Inundation time

The inundation time is determined by the depth, duration and frequency of the tidal flooding. Winterwerp et al. (2013) states that proper mangrove species should be planted at suitable locations above MHW. According to the Ecoshape BwN Guidelines (2018), the inundation time for mangroves should be between 7 and 13 hours a day (Figure 55). The related tidal elevation is:

the middle (from MSL) and upper intertidal elevation (till MHWS), which is at KT +1.50 mCD to +2.80 mCD. This is not exactly in line with Winterwerp et al. (2013), since MHWS (+2,80 mCD) would result in less than 7 hours inundation.

However, less inundation time can be tolerated to a greater extent by seedlings than by adult trees. Tolerance to flooding is species-dependent and can decrease when the plants are already stressed by other factors. *Avicennia alba* trees (trees, not seedlings) need a range of inundation of 400-800 minutes/day (about 7-13 h/day). In short, mangroves are always above mean-tide. (van Loon et al. 2007)

Other findings: the early colonisers (*Avicennia* spp and *Sonneratia alba*) were able to establish mainly in areas which were subjected to inundation between 40-60 times a month, but only within areas where the depth of inundation was no more than 0.3 to 0.4 m. (Lee, Tan, and Havanond, 1996)

✓ At the coastline the present mangroves grow at the tidal mudflats from +1.5 mCD to about +4.0 mCD average elevation (RHDHV, 2017d)

✗ This needs to be created at the breakwater location by elevating the bed level at least to +1.5 mCD. The average tidal range in the area is 3 m. In combination with the gradual beach profiles at KT, this results in an intertidal zone (mudflats) of approximately 1000 m. The area offers a variety of inundation times. Hence, the inundation time is not a limiting factor.

Recommendation:

- Detailed bed level measurements (e.g. reference level used for geotechnical survey)
- Sedimentation modelling study for prediction of sedimentation rates

### 5.1.3 Grade of the bed slope

Mangrove grow at wide convex mudflats with mild slopes at the location of the mangroves. These mild slopes gradually dampen wave energy and provide a wide intertidal flat. (Ecoshape BwN Guidelines, 2018) (Ecoshape Demak, 2018) In Singapore (Winterwerp et al., 2005) slopes of 1:400 to 1:650 have been measured near the shore.

✓ Large tidal mudflats are present at KT showing a coastal profile with slopes of 1:400 to 1:450 the first 1300 to 3000 m offshore (RHDHV, 2017a) although nautical charts indicate steeper slopes (1:240). Current slope at the site is about 1:450 (RHDHV, 2017a) [Slope at MSL – current slope](#):

- Depth contour drawing masterplan [1:450](#) (RHDHV, 2017a)
- Annex 1 breakwater model [1:467](#)
- Annex 3 bed level cross-section about [1:400](#) at location of the headland

✗ This needs to be created at the breakwater location by elevating the bed level and creating the right slope up to about +1.5 mCD. In deeper part (lower than +0 mCD = LAT) the slope could be too steep, reducing the intertidal area. This intertidal area needs to be wide enough to create space for a pioneer zone, middle zone and back zone species.

Recommendation:

- Detailed bed level measurements
- Wave modelling study to assess the effect of the bed slope on the incoming waves.

### 5.1.4 Width of mangrove forest

At least 150 m width of convex mudflat to have enough space to grow a sustainable forest (allow for lateral change of the forest) and to be effective in wave dampening. (Othman 1994) Moreover, a wide mudflat in front of the forest will reduce wave energy before it reaches the mangrove seedlings. In addition, a mudflat provides space for a natural rejuvenation. The forest should not be limited at the landward side by a dike or another immobile structure, as this would exclude this tidal water motion as well as landward migration in response to (relative) sea-level rise. (Ecoshape BwN Guidelines, 2018)



Winterwerp (Winterwerp et al., 2005) estimated that an intertidal mangrove belt of about 300-500 m is required to re-initiate the sedimentation process by the mangroves itself. If such an area is not available, a narrower mangrove belt can probably be applied, provided that compensation measures (permeable dams) are taken to reduce the erosion rate. The certainty that a mangrove forest will develop naturally decreases with decreasing width of the mangrove belt. The minimum width is estimated at a few 100 m's. Mazda (Mazda et al., 1997) states that every 100 m of mangrove forest results in 20% wave dissipation.

✓ The mangroves are scattered throughout the coast with various thickness of 5-100 meters inland from the coastline (see Figure 9). So, current system shows that mature mangrove forests can survive within a smaller width than 150 m.

✗ This needs to be created at the breakwater location by elevating the bed level to at least +1.5 mCD for a minimum width of 150 m. The intertidal area needs to be wide enough to create space for a pioneer zone, middle zone and back zone species.

### 5.1.5 Wave energy

Wave energy should not be too high to protect seedlings and juvenile mangrove trees. The maximum wave height should not exceed 1.5 m and the maximum period is 8 s. (Ecoshape Demak, 2018) A wide convex mudflat with mangroves can only be maintained if the hydrodynamic energy (wave action) is limited. Mature mangrove trees can withstand reasonable amounts of hydrodynamic energy, but the muddy subsoil can erode easily. Mangrove roots do not penetrate deep into the soil (~0.5 m), a few decimetres of erosion around the roots can result in uprooting and toppling of the tree. Pioneer species can survive disturbances better than slow growing *Rhizophora* spp., hence a natural mix and zonation of species allows for a greater resilience of the forest. (Ecoshape BwN Guidelines, 2018) After one year, pioneer species can already be 1 meter high and function as a wave dissipater. (Lee, Tan, and Havanond, 1996)

✓ As described in 4.2.7 [Waves](#), the significant wave height ( $H_s$ ) at KT rarely exceeds 1.5 meter (only 0.15% of the time). Swell waves (long wavelength) are mainly from the NNW and N sectors with  $H_s < 1.0$  m for most of the time (probability of exceedance 0.03%). The swell wave peak periods range between 4 s and 10 s. The site at KT is further characterized by very moderate wave conditions and wave energy is dissipated in a wide zone. The highest waves ever recorded do not exceed 3.2 m (sea waves NW), but apparently the existing mangroves can recover naturally after this event.

✗ At deeper parts wave energy could be too high. At the location of the breakwater wave energy should be limited by creating mild slopes which gradually dampen the wave energy. Installing permeable dams (to attenuate waves) could also be considered for the first phases. After all, the wave climate at KT is moderate, which will not limit the possibility of mangrove establishment.

### 5.1.6 Type of soil

Mangrove grow preferably in muddy soil conditions (clay and silty soil) but can also grow in sand and on former coral reefs (Tomlinson 1986, FAO 2006). The PH of the soil was found to be a critical factor in the survival and establishment of *Rhizophora* seedlings. If reclaimed areas are frequently subjected to inundations, the pH of the (acid) soil increases to about pH 7 resulting in a higher percentage of survival of saplings. (Lee, Tan, and Havanond, 1996). In general, when the coast is not muddy, it is an indication that the hydrodynamic energy might be too high for mangroves. (Ecoshape BwN Guidelines, 2018)

✓ The mudflats at KT mainly consists of silt and clay as can be seen in 4.2.2 [Geotechnical data](#). The general soil conditions comprise alternating layers of clay, silts and sands. Therefore, the soil conditions at KT are suitable for mangroves.

✗ KT is suitable for the establishment of mangroves if, and only if the same type of soil is used currently present at the mudflats. In Singapore, coarse sandy material was placed on top of the original clayey/sandy deposits. The absence of mud in the intertidal zone, supported the conclusion that this habitat was unsuitable for mangroves.

Recommendation: more detailed geotechnical research where the terms clay, silts and sands are better defined in grades (in mm).

### 5.1.7 Sedimentation rate and suspended sediments

To establish mangroves naturally, the sedimentation rate should be larger than 2-5 mm/year but smaller than 8-10 cm/year. Mangroves need sediment to sustain their elevation in the tidal range and to be able to keep up with sea level rise and subsidence. Sustaining elevation can only be achieved if enough sediment is available. Damming rivers upstream and constructing coastal structures which interfere with the littoral transport may therefore harm mangroves. On the other hand, too much sedimentation will smother the shoots (seedlings) or pneumatophores (aerial roots) and cause mortality. Sedimentation is closely linked with the tidal regime, wave climate and morphology (Ellison 1998, Adame et al. 2010, van Santen et al. 2007, Horstman et al. 2011). Suspended sediment concentration in natural forests was measured to be around 300-600 mg/l, sometimes up to 1000 mg/l. (Ecoshape BwN Guidelines, 2018)

✓ It is estimated that the coastline is quite stable and that the planned construction will not lead to excessive coastline instability risks or to large coastline changes within a short period of time. (RHDHV, 2017d) Since spits at river mouths and suspended sediment is observed from aerial images (Figure 29), and the fact that the coastline is stable, continuous sedimentation will probably not limit the establishment.

Further study into the coastal morphodynamics at the location of the breakwater is recommended. (RHDHV, 2017d)

### 5.1.8 Tidal currents

The convex tidal mudflat cannot be maintained and mangroves cannot establish if the tide-induced currents are too high. (Ecoshape BwN Guidelines, 2018) The coastal area must be protected from lateral transport of sediment. Tide-induced currents should not exceed a few dm/s. (Winterwerp et al., 2005) Tide-induced sedimentation should be larger than wave-induced erosion. (Winterwerp et al., 2013) See Figure 58.

✓ The maximum recorded current offshore was about 0.90 m/s towards the SE. Residual (ocean) current is 0.10 to 0.25 m/s to the SE.

✗ At the location of the breakwater the tidal currents could be too high. Tidal currents should be limited by installing permeable dams perpendicular to the main wave direction. Further study into current-patterns around the breakwaters is recommended.

### 5.1.9 Connectivity

Natural establishment will start with germination of pioneer species. They will be succeeded and supplemented by middle zone species. When pioneer species are already present in the system the existing forest can expand and supply seeds. (Lee, Tan, and Havanond, 1996) Proximity to other mangrove forests is a plus since mature mangrove forests supply diaspores. If this is not the case, artificial seeding/planting is necessary. (Ecoshape BwN Guidelines, 2018)

✓ The existing mangroves are scattered throughout the coast with various thickness of 5-100 meters inland from the coastline (see Figure 9). An exploratory study of mangrove species at the project area is already executed and pioneer species like *Avicennia* spp. are identified in the system. Depending on the currents and distance, propagules (explanation) may arrive at the location, but this needs to be checked by testing if propagules are found at KT in the period that mangroves further away produce them.

### 5.1.10 Redox

Mangrove need a redox of 150 mV to - 400 mV. (Ecoshape BwN Guidelines, 2018)

✓ No measurements or literature about the redox parameter are available. To determine this parameter, field measurements are required. The main purpose of measuring the redox potential is to ensure that anoxic conditions will not limit mangrove rooting. (Ecoshape BwN Guidelines,

2018). It is likely that the redox potential of the upper layers of sediment at KT is suitable for mangroves, since mangroves are already present nearby.

### 5.1.11 Salinity

This condition is widely considered as one of the most important factors. Most mangroves do not just need salt water to grow, they have the competitive advantage over other plants because they can also grow in salt water. The resistance against salinity depends on the duration of inundation and the life stage of the tree. Seedlings can resist less salinity than adult trees and in general the tolerance to salinity increases with the age of the tree. (Kathiresan & Bingham, 2001) Salinity is influenced by precipitation and fresh water supply from rivers. In general, mangroves grow preferably in fresh to salt water with a salinity of 3-27 ppt. (Ecoshape BwN Guidelines, 2018) Fresh water supply is important for mangroves to grow. (Winterwerp et al., 2013)

Salinity levels of the tidal water are critical in the survival of some species of *Avicennia* as is evidenced by (Lee, Tan, and Havanond, 1996). However, this research was focussed on mangrove establishment along the rivers inland related to low salinity levels. A lack of salt water (upstream) has a more negative impact than a lack of fresh water supply at the coast.

✓ Salinity maps of the strait of Malacca show about 31 psu (NE monsoon season) – 32 psu (SW monsoon season) at the top layer of the water column, but locally several rivers debouch influencing the salinity near the coast. It is likely that the current input of freshwater is sufficient.

✗ Mangroves need freshwater input. At KT, several rivers debouch and seasonally the area receives large amounts of precipitation. The current geometry (deep trench) of the coastline supports flushing of the freshwater by the tide. Coastal structures may block this and at some location the salinity might be too high for mangroves.

Recommendation: a study about the influence of outflowing rivers in the system on the salinity of the seawater and the influence of the breakwaters. A tactical decision has to be made about the location of outflowing rivers.

### 5.1.12 No pollution or eutrophication to water and soil

Mangroves are sensitive to oil spills due to clogging of pneumatophores (aerial roots) (Duke et al. 1997) and high nutrient inputs transported along with the sediment (e.g. wastewater). These nutrients increase the biomass above the ground and reduces the resilience of mangroves to changes. (Lovelock et al. 2009)

✓ There is no indication that, at present, contamination is a problem at KT but port and industrial activities and run-off from a densely populated area might cause pollution. High nitrogen load might be an issue, as several drains/rivers discharge at the future location of the breakwater. High nutrient loads pose a problem for matured mangrove trees and are not considered as a limiting factor for the germination phase. If high nutrient load were a problem, only small mangrove trees should be present at KT. As this is not the case, pollution is (yet) probably not a limiting factor for mangrove establishment. (Ecoshape BwN Guidelines, 2018)

Recommendation: Pollution and nutrient inputs should be monitored during construction and development of terminals and industries.

### 5.1.13 Time of the year

During monsoon, the hydrodynamic energy (wave action and current) in the system is too high to maintain the wide convex mudflat and too high for seedling and juvenile mangrove trees to grow. For natural establishment of mangroves, studies (Tim van Domburg, 2018) show that 'windows of opportunities' occur when the average water level is low, the waves are not too high, and pollination occurs. According to Balke et. al (2011) mangroves need to be planted within these 'windows of opportunities'. In Demak (Java), the needed time for natural accretion was 2-5 years and the rate of mangrove recovery was 3-5 years. (Ecoshape Demak, 2018)

Although it cannot be said with certainty when the fruiting seasons of the dominant mangrove species exactly occur, based on the monthly average water levels, in Demak it seems that

February–April and August–September are the best periods for mangrove establishment (Tim van Domburg, 2018). According to Winterwerp et al. (2005), the weather in the Gulf of Bangkok is dominated by the SW-monsoon in the months May–September and by the NE-monsoon during the months November–February.

✓ At KT the monsoon is hard to define but the dry season is from May to September. Windows of opportunities within this dry season occur when the hydrodynamic energy is limited, and seeds are supplied by the mature mangrove forests. Most of the rainfall, about 1500–3000 mm/year, falls in September to November (RHDHV, 2017b). In this period, the hydrodynamic energy is likely to be too high.

Recommendation: protection of seedlings and juvenile mangrove trees by constructing permeable dams. Further study for identifying the windows of opportunity at KT should be executed.

### 5.1.14 Mangrove species and living organisms

Next to the abiotic conditions above, a biotic condition is the presence of pioneering species like *Avicennia* spp. *Sonneratia* spp. (Ecoshape BwN Guidelines, 2018). It is important to understand the ecology of the mangrove species at the site, the patterns of reproduction, propagule distribution, and successful seedling establishment. (Winterwerp, 2014) In South-East Asia the following pioneering and non-pioneering species are present:

- Pioneers
  - *Avicennia* spp. (present at KT)
  - *Sonneratia* spp.
- Non-pioneers
  - *Rhizophora* spp., also called tall-stilt and loop-root mangrove (present at KT)
  - *Bruguiera* spp., also called oriental mangrove (present at KT)
  - *Ceriops* spp.
  - *Xylocarpus* spp.
  - *Heritiera* spp.

Natural seedling establishment will start with germination of pioneer species. They will be succeeded and supplemented by middle zone species. (See Figure 55). After one year, pioneer species can already be 1 meter high and function as a wave dissipater. When pioneer species are already present in the system the existing forest can expand and supply seeds. (Lee, Tan, and Havanond, 1996).

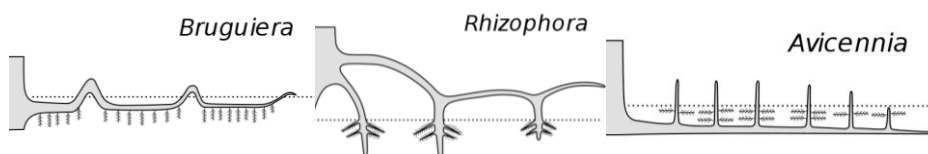


Figure 54 Names of several root systems of mangrove trees (Tomlinson 1986, FAO 2006)

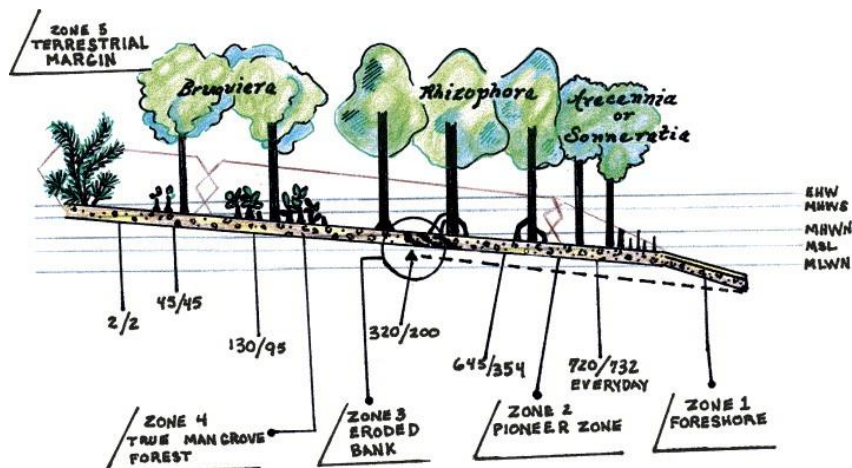


Figure 55 Mangrove species related to elevation/location at the shore (Ecoshape BwN Guidelines, 2018)

According to Wesenbeeck (2018), it is important to create diversity in species by creating more zones of elevation. When a disease strikes, the risk of losing the whole forest is minimised since some species may survive. In creating this diversity, living organisms play an important role on:

- **Bioturbation:** burrowing crabs, worms and other benthic organisms fulfil an important ecosystem function for the mangrove trees, as their burrows aerate the soil and support flushing of salt. A healthy population of benthic fauna is therefore necessary. (Stieglitz et al. 2000)
- **Pollination:** if there is no pollination, there are no propagules available for natural mangrove establishment and rejuvenation of an existing forest. Habitat requirements like mentioned in 5.1.4 **Width of mangrove forest**, have to be met to sustain the pollinator population like bats and insects. (Tomlinson 1986, FAO 2006).
- **Barnacle formation:** when sufficiently long submerged barnacles grow on the seedling, the seedlings become unstable due to the extra weight, resulting in increased mortality (Angsupanich and Havanond, 1996).

✓ Api Api (*Avicennia alba* and *Avicennia officinalis*) mangroves are present at KT. Since there are mature mangroves forests nearby, important living organisms are also expected to be in the proximity.

Recommendation: further research about the feasibility of replacing mature mangrove trees from the headland to the breakwater location and identification of suitable mangrove species for the pioneer and middle zone.

## 5.2. Evaluation of required conditions: checklist

Table 3 can be used to check whether a certain location is suitable or can be made suitable for the establishment of mangroves. The conditions can be divided into four spheres: biosphere, hydrosphere, lithosphere and atmosphere. The biosphere includes all conditions regarding living organisms (in Table 3: biotic conditions). Since the hydrosphere (all water related conditions), lithosphere (soils and rocks) and atmosphere, (weather and climate), are closely related, these three spheres are categorized under 'abiotic conditions'.

From the table below and the determination flowchart (Ecoshape BwN Guidelines, 2018) given in [Appendix E](#), a first-order assessment of the suitability for mangroves at KT can be made. This flowchart is also used to determine the potential of a site for 'East Coast Parc' a recreational coastal park in Singapore. For this case, it was concluded that the soil conditions were not suitable for mangroves. Besides, the large-scale morphology (coastal profile and soil conditions) prevented mangroves to grow at 'East Coast Parc', despite the presence of propagule supply.

For KT there are technically no showstoppers (limiting factors) identified for the establishment of mangroves. Some conditions (indicated with a **X**) require special attention and need to be created at the location of the mangroves. However, at deeper water the financial feasibility of creating these conditions will probably limit the applicability of mangrove establishment. Section 5.4. [Preliminary design of the mangrove breakwater](#) will further elaborate on this.

✓ means no consequence on breakwater design, ✓X consequence on breakwater design

To fully assess the suitability for mangrove forests one should have additional ecological expertise on mangroves. In the next section a combination of planting mangroves and natural establishment is discussed.

Table 3 Summary checklist feasibility study for applying mangroves

	Necessary condition	Source	Condition naturally present at KT, or need to be engineered	Check
<b>Abiotic</b>				
1.	Climate: tropical or subtropical climate.	(Ecoshape Demak, 2018)	Tropical climate.	✓
2.	Inundation time: between 7 and 13 hours a day.	(Ecoshape BwN Guidelines, 2018) (Lee, Tan, and Havanond, 1996)	Needs to be engineered at the site. This is closely linked with the slope of the bed, elevation, and width of the forest. At around MSL the inundation time is about 12 h (Figure 50). This needs to be created at the breakwater location by elevating the bed level at least to +1.5 mCD. The average tidal range in the area is 3 m. In combination with the gradual beach profiles at KT, this results in an intertidal zone (mudflats) of approximately 1000 m. The area offers a variety of inundation times. Hence, inundation is not a limiting factor.	✓X
3.	Grade of the bed slope: wide convex mudflat with a mild slope.	(Ecoshape BwN Guidelines, 2018) (Ecoshape Demak, 2018) (Winterwerp et al., 2005)	Wide tidal mudflats are already present, but this needs to be created at the breakwater location by elevating the bed level at least to +1.5 mCD. The average tidal range in the area is 3 m. In combination with the gradual beach profiles at KT, this results in an intertidal zone (mudflats) of approximately 1000 m. The area offers a variety of inundation times. Hence, this is not a limiting factor.	✓X
4.	Width of the mangrove forest: at least 150 m width of forest (mature trees) or Winterwerp states 300-500 m is required to re-initiate the sedimentation process naturally by mangroves.	(Ecoshape BwN Guidelines, 2018) (Winterwerp et al., 2005)	Needs to be created at the breakwater location by elevating the bed level to at least 1.5 mCD for a minimum width of 150 m to attenuate waves. The intertidal area needs to be wide enough to create space for a pioneer zone, middle zone and back zone species.	✓X
5.	Wave energy: not too high to protect seedlings and juvenile mangrove trees. The maximum wave height should be 1.0 m to 1.5 m and the maximum period 8 s.	(Ecoshape BwN Guidelines, 2018) (Ecoshape Demak, 2018) (Lee, Tan, and Havanond, 1996)	The significant wave height ( $H_s$ ) at KT rarely exceeds 1.5 m (only 0.15% of the time). Swell waves (long wavelength) are mainly from the NNW and N sectors with $H_s < 1.0$ m for most of the time (probability of exceedance 0.03%). The swell wave peak periods range between 4 s and 10	✓X

			<p>s. The site at KT is further characterized by very moderate wave conditions and wave energy is dissipated in a wide zone. The highest waves ever recorded do not exceed 3.2 m (sea waves NW), but apparently the existing mangroves can recover naturally after this event. At deeper parts wave energy could be too high. At the location of the breakwater wave energy should be limited by creating mild slopes which gradually dampen the wave energy and installing permeable dams (to attenuate waves) could be considered for the first phases. After all, the wave climate at KT is moderate, which will not limit the possibility of mangrove establishment.</p>	
6.	Type of soil: muddy preferred.	(Ecoshape BwN Guidelines, 2018) (Tomlinson 1986, FAO 2006) (Lee, Tan, and Havanond, 1996)	The mudflats at KT mainly consists of silt and clay as can be seen in Figure 27. The general soil conditions comprise alternating layers of clay, silts and sands. Therefore, the soil conditions at KT are suitable for mangroves. KT is suitable for the establishment of mangroves if, and only if the same type of soil is used currently present at the mudflats. In Singapore, coarse sandy material was placed on top of the original clayey/sandy deposits.	✓X
7.	Sedimentation rate and suspended sediments: > 2-5 mm/year, < 8-10 cm/year.	(Ecoshape BwN Guidelines, 2018) (Ellison 1998, Adame et al. 2010, van Santen et al. 2007, Horstman et al. 2011)	It is estimated that the coastline is quite stable and that the planned construction will not lead to excessive coastline instability risks or to large coastline changes within a short period of time. (RHDHV, 2017d). Since spits at river mouths and suspended sediment is observed from aerial images (Figure 29) and the fact that the coastline is stable, continuous sedimentation will probably not limit the establishment.	✓
8.	Tidal currents: tide-induced currents should not exceed a few dm/s.	(Ecoshape BwN Guidelines, 2018) (Winterwerp et al., 2005)	The maximum recorded current offshore was about 0.90 m/s towards the SE. Residual (ocean) current is 0.10 to 0.25 m/s to the SE. Tidal currents should be limited by installing permeable dams perpendicular to the main wave direction.	✓X

Necessary condition	Source	Condition naturally present at KT, or need to be engineered	Check
9. Connectivity: proximity to other mangrove forests.	(Ecoshape BwN Guidelines, 2018) (Lee, Tan, and Havanond, 1996)	The existing mangroves are scattered throughout the coast with various thickness of 5-100 meters inland from the coastline (see Figure 9). An exploratory study of mangrove species at the project area is already executed and pioneer species like <i>Avicennia</i> spp. are identified in the system. Depending on currents and distance, propagules (explanation) may arrive at the location, but this needs to be checked by testing if propagules are found at KT in the period that mangroves further away produce them.	✓
10. Redox: 150 mV to - 400 mV.	(Ecoshape BwN Guidelines, 2018)	No measurements or literature of the redox parameter are available. To determine this parameter, field measurements are required. The main purpose of measuring the redox potential is to ensure that anoxic conditions will not limit mangrove rooting. It is likely that the redox potential of the sediment at KT is suitable for mangroves, since mangroves are already present nearby.	✓
11. Salinity: 3-27 ppt.	(Ecoshape BwN Guidelines, 2018) (Kathiresan & Bingham, 2001) (Winterwerp et al., 2013) (Lee, Tan, and Havanond, 1996)	Mangroves need freshwater input. At KT, several rivers debouch and seasonally the area receives large amounts of precipitation. The current geometry (deep trench) of the coastline supports flushing of the freshwater by the tide. Coastal structures may block this and at some locations the salinity might be too high for mangroves.	✓X
12. No pollution or eutrophication to water and soil.	(Ecoshape BwN Guidelines, 2018) (Duke et al. 1997) (Lovelock et al. 2009)	There is no indication that, at present, contamination is a problem at KT but port and industrial activities a run-off from a densely populated area might cause pollution. High nitrogen load might be an issue, as several drains/rivers discharge at the future location of the breakwater. High nutrient loads pose a problem for matured mangrove trees and are not considered as a limiting factor for the germination phase.	✓



13. Time of the year: no monsoon.	(Ecoshape BwN Guidelines, 2018) (Tim van Domburg, 2018) (Balke et. al, 2011) (Ecoshape Demak, 2018)	At KT the monsoon is hard to define but the dry season is from May to September. Windows of opportunities within this dry season occur when the hydrodynamic energy is limited, and seeds are supplied by the mature mangrove forests. Most of the rainfall, about 1500-3000 mm/year, falls in September to November (RHDHV, 2017b). In this period, the hydrodynamic energy is likely to be too high.	✓
<b>Biotic (bacteria, vegetation etc.)</b>			
14. Pioneer species and living organisms: Avicennia spp. Sonneratia spp.	(Ecoshape BwN Guidelines, 2018) (Winterwerp, 2014) (Lee, Tan, and Havanond, 1996)	Api Api (Avicennia alba and Avicennia officinalis) mangroves are present at KT. Since there are mature mangroves forests nearby, important living organisms are also expected to be in the proximity.	✓

### 5.3. A combination of artificial measures and natural processes

From the first-order assessment of the previous chapter is concluded that the conditions at KT meet the habitat requirements for mangroves to grow but for several conditions measures are needed to make it suitable for juvenile mangrove trees (in Table 3 indicated with **X**). According to Winterwerp (2005), the mangrove establishment can be promoted by artificial infill with mud to raise the bed to mean sea level and/or by planting with juvenile mangrove trees. (Winterwerp et al., 2005)

In this section, first raising the bed is discussed, and subsequently the establishment and survival of mangroves. BwN prescribes to make use of the natural processes in the design. This can be done by: 1) installing permeable dams which facilitate accretion of suspended sediments resulting in a 'naturally growing breakwater' and 2) by creating the right conditions for mangroves to attract a variety of mangrove species and thereby creating a more resilient and sustainable breakwater.

#### 5.3.1 Raising the bed artificially and by natural processes

To include mangroves in the breakwater design, the grade and elevation need to be according to the conditions mentioned in Table 3. This can be done artificially by trailer Suction Hopper dredgers (or Cutter Suction dredgers) as proposed in the current master plan or naturally by placing permeable dams. The latter has been applied very successfully for centuries in the Netherlands and in Germany to create salt marshes and floodplains protecting the sea defence. Permeable structures are used to: (Ecoshape Demak, 2018)

- Create sheltered zones with reduced flow velocities and wave impact. In other words, to create areas of reduced orbital velocities and turbulence to provide sufficient wave energy dissipation (by using suitable fill material).
- Thereby facilitating accretion of suspended sediments.

Generally, permeable structures are fence-like structures and consist of two rows of vertical poles with (brushwood) fill in between. The permeability of dams needs to be sufficient to let sediments pass through (sufficient tidal through flow) and wave reflection should be limited. Recently, several types and configurations of permeable dams have been tested at Demak (Java, Indonesia) as part of the coastal defence. At some locations at Demak, **the accretion was in the order of 0,5 to 0,8 m in three months.** (Tom Wilms, Ecoshape Demak, 2018)

**Key findings of the project at Demak:**

Based on experience in Demak, the permeable dams should be placed at a distance of 100 m from the shoreline because the accretion starts directly behind the dams. Larger distances resulted in deeper parts in between the parallel dams (no connectivity). Besides, several alternative materials are proposed for each component of the permeable structure (see table 1 of Ecoshape Demak, 2018). Type of material (coatings or not) and especially the type of fill material still needs to be tested in further detail. The brushwood used in Demak worked well but because brushwood floats, it damaged the back row of the vertical and horizontal bamboo poles. Ideally, the fill material is heavier than water and durable<sup>13</sup>. In addition, the T-shaped ends of the dams (to prevent scour) need to be analysed in further detail. (Ecoshape Demak, 2018)



Figure 56 T-shaped ends at openings and at the end of each longshore structure (Ecoshape Demak, 2018)

**For KT**, an initial (artificial) bed elevation until around +1,61 mCD (just above MSL) is needed to place permeable dams (with vertical poles of 5 m) and initiate accretion of suspended sediments (see calculations on the next page). After placing the permeable dams, the bed level behind the dams is likely to raise naturally. Given the findings of the pilot project at Demak, and if enough sediment is available in the system, the bed level can accrete up to around +2,00 mCD in just three months (resulting in less **inundation time**). This effect can be strengthened by agitation dredging (Winterwerp, 2014), which is the mechanically stirring of the seabed and therefore nourishing the system with mud. Furthermore, these permeable dams create the right conditions for mangroves to grow and actually have the same function as mature mangroves (See Figure 57).

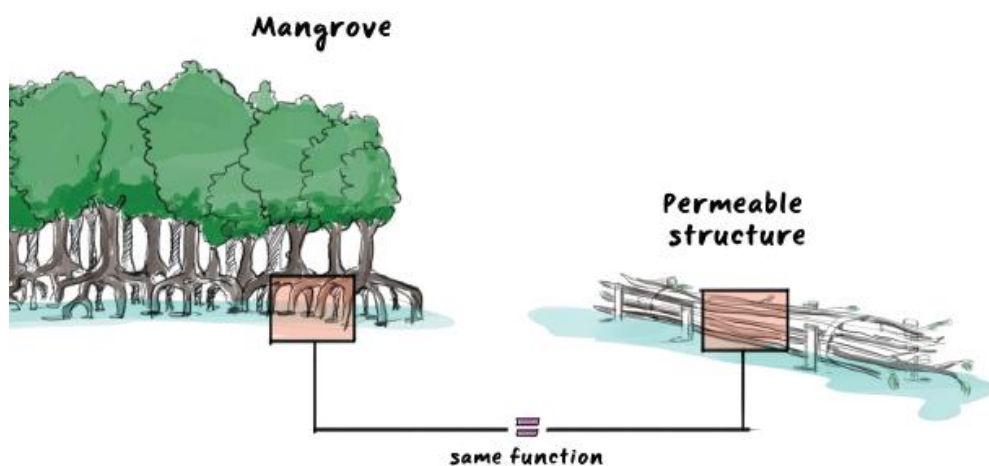


Figure 57 Permeable structures mimic the root system of mangroves that breaks incoming waves, reduce orbital velocities and turbulences and trap sediments (Ecoshape Demak, 2018)

<sup>13</sup> Interview T. Wilms (Witteveen + Bos) [Appendix F](#)

Functional requirements of mangrove recovery (Ecoshape Demak, 2018):

*“Using permeable structures to trap sediment in combination with mangrove recovery is suitable in **muddy coastal systems** where there is still a **large availability of fine sediment** (mud) and where mangroves grew previously. It is optimal when there are still mangroves present in the surrounding landscape. Fruit, propagules, and seedlings of the existing trees can then be naturally transported to locations where they can grow.”*

Application of permeable bamboo fences in the lower Mekong delta (Ecoshape Demak, 2018):

*“The wave transmission effect of the permeable dams is sufficient to reduce wave heights significantly and stimulate sedimentation on the sheltered side. The construction is cost-efficient and often more feasible than massive structures on the soft soil.” See Figure 58.*

#### **Calculation determining the initial bed level (+1,61 mCD) needed to initiate natural processes**

Using permeable dams for the breakwaters at KT. Theory and results at Demak, 0,5 – 0,8 m per 3 months accretion. This will influence the level (h) of the initial breakwater design.

According to Technical Guidelines of Permeable Dams, the top of the vertical poles needs to be at least 0,5 m above MHWS. Since MHWS at KT is +2,78 mCD (see table below), **top of vertical poles is at least (MHWS + 0,50m) +3,28 mCD**. Length of the poles is 5,0 m (is actually the maximum length used at Demak for construction reasons, pushed into the ground by people), where 2/3<sup>rd</sup> needs to be pushed into the soil = 3,33 m in (stiff) clay and at least **1,67 m above the bed level** (1/3<sup>rd</sup> of the pole). **So, bed level at about: + 3,28 mCD - 1,67 m = + 1,61 mCD would be sufficient** according to “Permeable Structures Technical Guidelines #4” (Ecoshape Demak, 2018)

In current design described in 5.4 [Preliminary design of the mangrove breakwater](#), there is a stretch of about 150 m which has a bed level + **1,6 mCD or higher**.

Water level		Level (m above LAT)
Highest Astronomical Tide	HAT	+2.98
Mean High Water Springs	MHWS	+2.78
Mean High Water Neaps	MHWN	+2.10
Mean Sea Level	MSL	+1.52
Mean Low Water Neaps	MLWN	+0.90
Mean Low Water Springs	MLWS	+0.19
Lowest Astronomical Tide	LAT	+0.00

Source: RHDHV Annex 2

### **5.3.2 Planting mangrove trees and natural establishment**

The conditions described in section 5.1. [Conditions for the \(natural\) establishment of mangroves](#) mainly focused on the suitability of a site for natural establishment of mangroves. Engineering the conditions which are favourable for natural establishment yields higher success rates of restoration projects than planting mangroves on any convenient mudflat. When mangroves establish naturally, natural competition and succession of species will result in a natural forest structure, density and species zonation. (Ecoshape BwN Guidelines, 2018). But growing takes time. In Singapore natural seedlings were dispersed to the site from a mature mangrove stand by the tide and these established into a mature stand within 6 years. (Lee, Tan, and Havanond, 1996) Mangrove recolonization using permeable structures is currently being applied in Central Java (Indonesia), in the Mekong Delta (Vietnam) and near Paramaribo (Surinam).

Often the conditions described for natural establishment are stricter than those described for (re)planting programs. Combining the right conditions for natural establishment and planting juvenile trees is likely to result in higher succession rates of established seedlings than only replanting requirements. An example of such a condition is the required width of the mangrove forest. According to Winterwerp (2005) an intertidal mangrove belt of about 300 to 500 m is required to re-initiate sedimentation processes but by artificial sediment nourishment and planting juvenile mangrove trees, a mangrove belt of about 150 m is already sufficient.

Planting juvenile mangrove trees, planting seedlings and (re-)planting mature mangrove trees that need to be cut down requires additional ecological expertise. A mangrove 'transplantation machine' may be developed to realise this. However, this is not part of the scope of this research.

Conclusion Lee 1996 (Lee, Tan, and Havanond, 1996):

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*“Regeneration of mangroves on reclaimed lands in Singapore can be achieved through the **natural process** if sources of propagules are present nearby, and **direct planting** if the sources are some distance away or to accelerate the establishment of the vegetation. However, many factors such as the frequency and depth of inundations, gradient and elevations of the site, salinity of the water and the pH of the soil have to be carefully considered so that the conditions of the site are favourably maintained for the survival and the establishment of the vegetation.”*

---

Close to the existing mangrove forest, natural establishment can be stimulated which will probably result in a natural extension of the existing mangrove forest in seaward direction. However, further offshore this will take time and natural recruitment will probably not provide enough successfully established seedlings. Therefore, planting juvenile mangroves and seedlings offers a more feasible solution. Eventually, the mature mangrove trees that need to be cut down for port extension can be replaced (replanted) at the location where the right conditions are engineered. Additional ecological expertise is needed to assess this last option. In addition to dissipating waves, mangroves also have the other advantages:

- Remove nutrients from the water, thus reducing the Biological Oxygen Demand.
- Provides shelter for species and has a nursery function for juvenile marine animals (such as shrimps, crabs and fish), with positive effect on coastal fisheries. (Winterwerp, 2005)
- Provides organic matter that forms the basis of the local food web including many shrimps, crabs and fish species. (Winterwerp et al., 2005)
- Increase nesting, resting and feeding habitat for migrating and local birds.
- Carbon sequestration.
- Providing wood and charcoal.
- Water quality improvement.
- Can develop into sustainable barrier which grows with (relative) sea level rise by trapping sediments.

Note that a newly developed mangrove forest has in the beginning less advantages than the existing mature mangrove forest. The main advantages of mangroves compared to coastal structures is the influx of sediments which is supported by convex mudflats with mangroves. As mentioned in 5.1.8 [Tidal currents](#), the waves generally take sediment away, while the tide brings sediment in. For a natural mangrove system there is a natural balance, in contrast to hard structures where reflection of the waves results in a net erosion in front of the structure. See Figure 58.

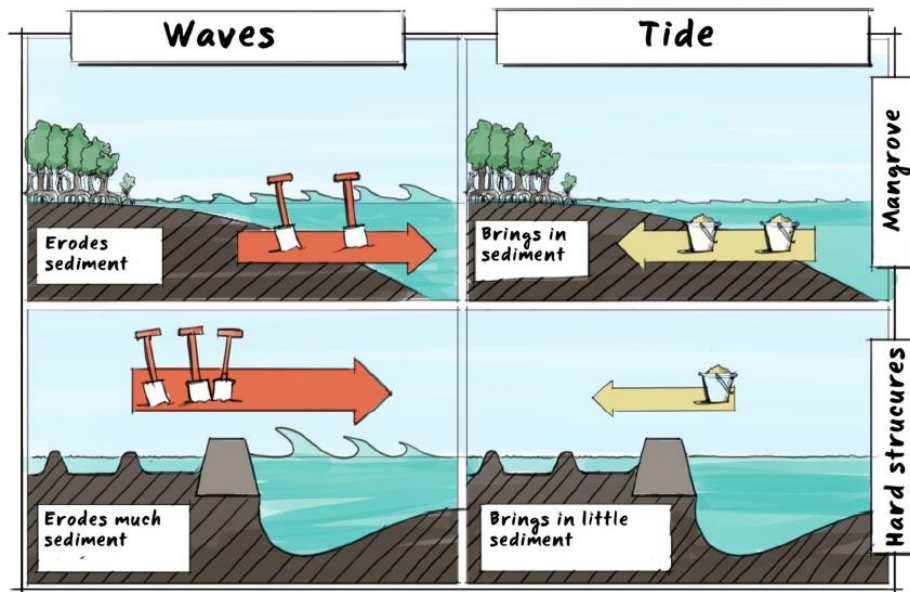


Figure 58 Mangroves versus 'hard' structures (Winterwerp, 2014)

The use of hard structures (e.g. using stones and concrete) on muddy beds have the following disadvantages:

- Wave reflection: much higher erosive stresses
- Large water content: small bearing capacity
- Small permeability: risks of liquefaction
- Solid dikes need solid foundation: bed protection
- Likely to be very expensive, also in maintenance (Winterwerp et al., 2005)

#### 5.4. Preliminary design of the mangrove breakwater

The main conditions determining the design of the mangrove breakwater are: the bed elevation (inundation time), the grade of the bed and the needed width of the mangrove forest. The other conditions do not have major consequences for the dimensions of the breakwater. In this section a preliminary design of the initial shape of the breakwater is made. In this design it is assumed that permeable dams will initiate natural accretion followed by a combination of mangrove planting and natural establishment near the coastline.

##### 5.4.1 Location of the breakwater

The preliminary design of the mangrove-based breakwater is located at approximately the same location as proposed in the current master plan. However, as described in 4.6.2 [The onshore alternative](#), the 'left' breakwater is located at 'right' side of the river and the 'right' breakwater is shifted a couple of 100 meters to the right. There are two main reasons to choose this location:

- The two river branches near Kuala Indah village can still flow out on the left side of the 'left' breakwater. To maintain a large enough basin, the 'right' breakwater is also replaced to the right (no residential areas).
- For the current master plan the technical requirements (diameter of turning circle, number of berths) are considered by experts and an initial wave modelling is done. Therefore, the configuration of the mangrove breakwater is not reconsidered.

For the quantity of needed fill material and cost estimation of the construction, the bathymetry (depths) at the location of the original breakwater are quite well identified and described. Since a detailed bathymetry chart is missing, the depths are derived from ones used for the current master plan.

At five locations of the 'right' breakwater, the depth is determined resulting in four parts with different characteristics. It is assumed that the depth along a part increases linearly. In the remaining of this section, only a preliminary design for the 'right' breakwater is made, since the 'left' breakwater dimensions match with part 1 and part 4. See Figure 59.

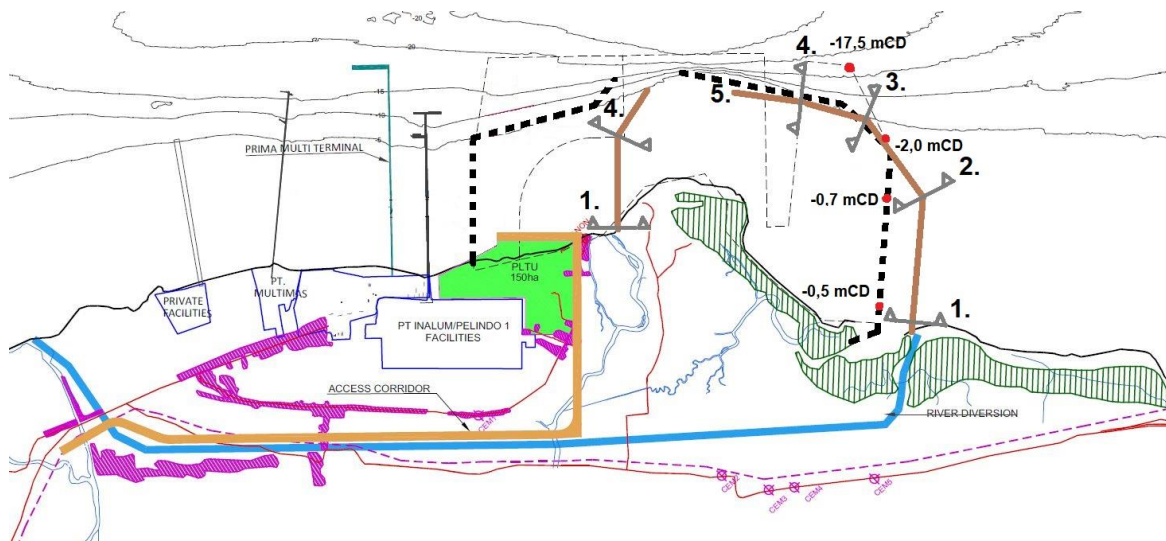


Figure 59 Location of the mangrove breakwater including parts 1-4, dotted line gives an indication of the original location of the breakwater, in red depth measurements (adapted from RHDHV, 2017a)

### 5.4.2 Mangrove-based protection until the deepest part of the breakwater

In the ideal situation the mangroves can be applied to the total length of the breakwater. To meet the right conditions for mangroves to grow the slope of bed must be mild ( $s_1 = 1:400$ ) from LAT to MSL and an initial width of at least 150 m must be created. The height of the initial cross-section (+ 1,6 mCD) is required to install permeable dams (as calculated in 5.3.1 [Raising the bed artificially and by natural processes](#)) and therefore initiate the sedimentation process behind the dams is just above MSL. Part 1 has a length of 1500 m and starts at a depth of -0,5 mCD (at the coastline) and ends in seaward direction at a depth of -0,7 mCD resulting in an average height ( $h =$  bottom to crest at + 1,6 mCD) of 2,2 m. Since the seabed level along this part is located just under LAT, the slopes are mild almost until the seabed, where a small toe of coarse sand/stone is located. The slope of this coarse material ( $s_2$ ) is estimated to be 1:3. (see Figure 60 and [Appendix G](#))

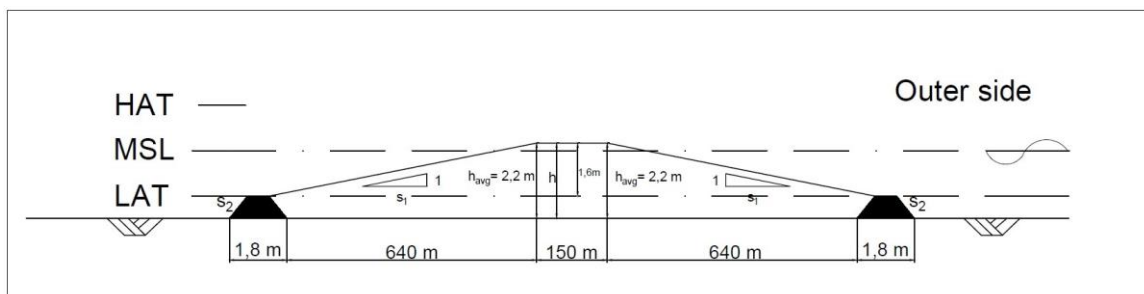


Figure 60 Cross-section part 1 with  $h = 2,1$  m to  $h = 2,3$  m and  $s_1 = 1:400$  and  $s_2 = 1:3$  (author)

Part 2 has a length of 910 m and starts at a depth of -0,7 mCD and ends in seaward direction at a depth of about -3,3 mCD. The concept is the same as part one, resulting in a larger toe of coarse material. The average height ( $h$ ) of this part is 3,5 m.

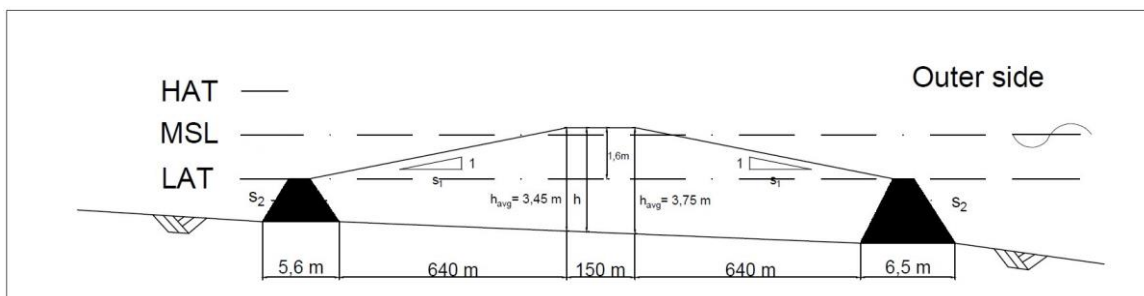


Figure 61 Cross-section part 2 with  $h_{left} = 2,3$  to 4,6 m and  $h_{right} = 2,3$  m to 5,2 m (author)

Part 3 and 4 (both 700 m in length) are based on the same concept but these parts are partially located in deeper water near the deep trench. This results in a larger toe of coarse material on the outer side of the breakwater. The average height ( $h$ ) under the crest of part 3 is about 6,0 m and of part 4 is about 8,4 m.

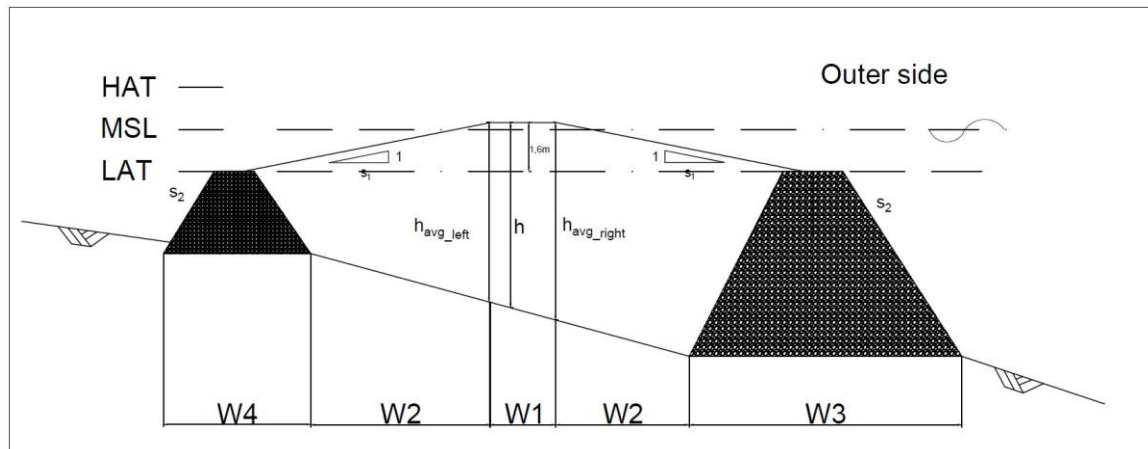


Figure 62 Cross-section part 3 and 4, see [Appendix G](#) for dimensions (author)

As can be seen in the Table 4 (and [Appendix G](#)), the total volume needed to construct this breakwater is about 25 million  $m^3$ . As calculated in Table 1 [Design requirements compiled with available documents of RHDHV \(RHDHV, 2017a\)](#), the difference between total estimated quantity of dredged material and estimated fill of land reclamation is about 24 million  $m^3$ . So, for the proposed breakwater this dredged material could be reused in the design.

Table 4 Estimated needed volume of fill material for the mangrove breakwater design

Part	Vneeded [ $m^3$ ]
1	3,19E+06
2	3,77E+06
3	8,22E+06
4	10,1E+06
Total	25,3 million

### 5.4.3 Partially applied mangrove-based protection

The required volumes of part 3 and 4 are significantly larger than part 1 and 2. In addition, as mentioned in 5.1.11 [Salinity](#), the salinity levels of the tidal water are critical in the survival of some species of *Avicennia* and could be too high at a large distance from the river (Lee, Tan, and Havanond, 1996). For part 3 and part 4 it is difficult to allow for good manoeuvrability of the ships. The wave energy may also be too high in the deeper parts. For these reasons, a combination of mangrove-protection at shallow parts and a hard structure for the deeper parts is considered. This consensus requires special attention to the transition between the 'soft' and 'hard' part of the breakwater. At the transition where a combination of a hard structure and mangroves is made, the reflection of the waves against the hard structure should be limited (Figure 58). In Chapter 4 some assumptions turned out to be unfeasible:

- Initial elevation of +1.50 mCD (results in 8 hours a day inundation) but +1,60 mCD turned out to be feasible regarding the installation of permeable dams.
- Constructing the mangrove breakwater up to the -10 mCD depth contour but up to -5 mCD turned out to be feasible.
- A mild slope of 1:125 was assumed but after further study 1:400 turned out to be feasible.

## 5.5. Cost estimates of the preliminary designs of the mangrove breakwater

The average area of the cross-sections multiplied by the length of the related part gives the total volume required to construct the initial shape of the naturally growing mangrove breakwater. The unit rate used for supply and placing of sediment is 10 USD per  $m^3$ . This unit rate is also used for the current master plan, where the breakwater consisted mainly of coarse material (sand). Within this preliminary design, there is (still) no distinction made between the price of the fill material (dredged material) and the price of coarse material (toes). Since the largest amount consists of cheaper fill material (cheaper than 10 USD per  $m^3$ ), the cost estimate will probably be conservative. For the volume and cost calculations see [Appendix G](#).

Table 5 Estimated costs for supply and placing of the initial design of the mangrove breakwater

Part	Costs [USD]
1	3,19E+07
2	3,77E+07
3	8,22E+07
4	10,1E+07
Total	253,019441

In this cost estimation for the mangrove breakwater as proposed in 5.4.2 [Mangrove-based protection until the deepest part of the breakwater](#) the sum of the 4 parts is: 253 million USD. In the current master plan the SE breakwater costs 214 million USD. This first comparison shows that the costs are in the same order of magnitude. Note that:

- Constructing part 3 and part 4 as hard breakwater instead of the mangrove breakwater will probably result in lower costs.
- In this calculation reusing the dredged material (of the approach channel and basin) is not incorporated in the design, which will probably lower the unit rate used for supply and placing of sediment.

## 5.6. Phasing of the mangrove breakwater

Contrary to the original design of the breakwater, the mangrove breakwater is constructed in multiple phases:

1. Construct the initial breakwater to just above MSL (+1,6 mCD) like the cross-sections explained in 5.4 [Preliminary design of the mangrove breakwater](#).
2. Place at least two rows of permeable dams (distance in between 100 m) on top of the constructed breakwater. This will probably result in accretion behind the dams. (eventually a jetty on top of the breakwater).
3. Plant mangroves at locations where the bed level has risen naturally and stimulate expansion of the existing forest close to shore.
4. Remove the sediment of the inner side of the breakwater to the outer side if port development (phase 4) requires more space/depth for shipping. Expected in about 10 years according to the current master plan (in Singapore it took six years to develop a mature mangrove forest).

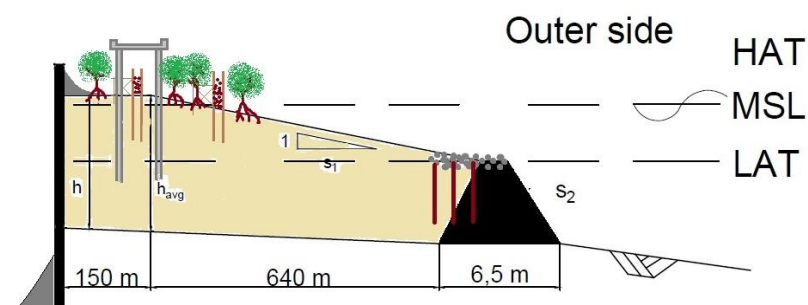


Figure 63 Final phase mangrove breakwater (author)



### 5.7. Effect of BwN solution on phasing of the port development

In the current master plan, phasing is proposed as described in 3.3.2 [Technical analysis and design requirements](#). Because the mangrove breakwater with mild slopes (catching sediment in the first years) is constructed in multiple phases as described in the previous section, a new phasing of the port development is proposed:

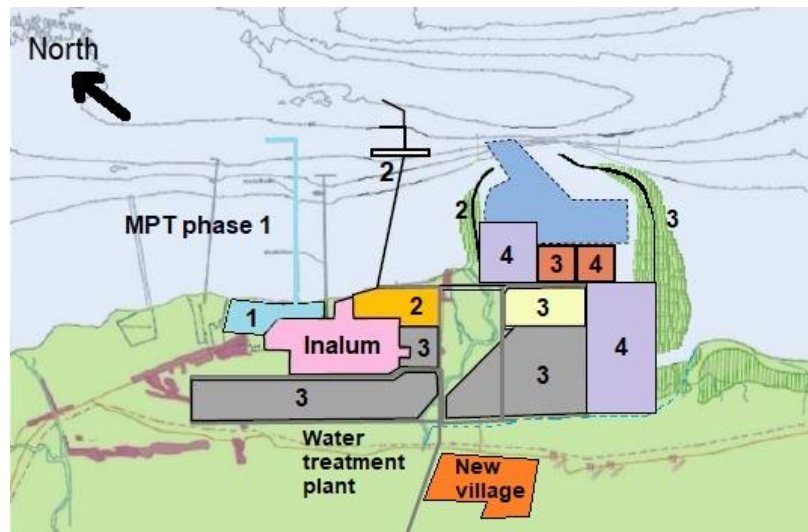


Figure 64 Indication of phasing influence by the development of the mangrove breakwater (author)

### 5.8. Risk and benefit assessment of the chosen BwN solution

Incorporating mangroves to fulfil a part of the function of the breakwater has multiple benefits but does also have related implementation risks. Because the growth of mangroves can be influenced by a lot of factors, the design should not be totally dependent on the function of the mangrove trees. As an alternative the installation of permeable dams (which have the same functions) will probably exclude part of those risks (Figure 58). Besides, a general risk of creating a basin in a muddy environment is the sediment flow (sediment trap) which result in large amounts of maintenance dredging. Other implementation risks:

- [The growth of mangroves can fail \(plants die\)](#) and in case of planting mangroves a certain fail/success rate has to be considered. The long-term survival rates are generally low at 10-20 %. Unsuccessful rehabilitation of mangroves can follow from wrong selection of species, unfavourable climate and site conditions such as winter temperature, sediment properties and morpho-hydrological factors, as well as a lack of post-management and monitoring. (Winterwerp et al., 2013) Erfteimeijer and Lewis (2000) states that mangrove reforestation on mudflats is not easy, it is often characterized by high [mortality rates caused by factors such as barnacle infestation, smothering or burial from excessive sedimentation, wave action](#) and so forth. However, in areas where mudflats are accreting success rates are likely to be higher. (Winterwerp et al., 2013)
- [The risks of liquefaction](#) during an earthquake can be mitigated by increasing the density of the existing sand and silt layers where these are loose, and taking measures to achieve a reasonable density in the fill material. Based on the information that is available, it appears that dynamic compaction may be the most economic method, but this will need to be verified when further soil information becomes available.” (RHDHV, 2017e)
- If the port complex does not directly connect to the shore the river can still discharge at its present location. However, there is still the danger of [blockage of the river mouth by deposition of the river sediment](#). In the present situation the tidal currents are able to transport the river deposition away from the river mouth. With the port complex in place the tidal current will no longer be able to flush away these depositions with the risk that the river mouth becomes blocked. (RHDHV, 2017e)
- [During storm events and/or high waves occurring](#), the mangrove trees fall down, as their root system does not provide sufficient anchoring anymore. (Winterwerp et al., 2005)

- Enhancing nature in a port project by for instance creating a new mangrove forest, [animals will be attracted](#). When the port needs to be expanded, the project organisation has to deal with the removal of these newly created habitats.
- There is a [risk of local subsidence](#) due to increased deep groundwater extraction by industries and urban area. When the slope of the seabed is about 1:400 an annual subsidence of 1 cm would result in a coastal retreat of 5 m/yr. However, the effect on the erosion process of the mangrove mud coast is expected to become only important on a time scale of about a hundred years. (Winterwerp et al., 2005)
- [Erosion on the downdrift](#) side of the port is expected, since the mangroves will trap sediment. However, it is estimated that the coastline is quite stable and that the planned construction will not lead to excessive coastline instability risks or to large coastline changes within a short period of time. (RHDHV, 2017d)
- [The mangrove-based protection is still in its infancy](#) since pilot projects at Java are still going on. Technically, more research has to be done into the placement criteria related to the structures stability because permeable dams are not breakwaters, but sediment trapping structures. Tests at KT should be carried out to determine whether mangrove stimulation really works at KT.

In section 5.3.2 [Planting mangrove trees and natural establishment](#) the advantages of (mature) mangrove forests are already mentioned. Using mangroves in the breakwater design will likely provides the following benefits:

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Instead of a traditional 'hard' breakwater, a breakwater is proposed with a mild slope of dredged material around MSL which 'grows' naturally by accretion behind permeable dams creating the right conditions for mangrove trees to establish. This mangrove protection can develop into a sustainable barrier which grows with (relative) sea level rise by trapping sediments.

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## 5.9. Changed view on the PoKT project

By applying the BwN approach to the PoKT project, the emphasis lies on the positive impact instead of the negative impact. By communicating this innovative approach to stakeholders, involving them and connecting to political agendas the PoKT development is expected to be widely supported. See column six in [Chapter 6](#). The main changes are:

- In the first three phases the breakwater is naturally growing by accretion behind the permeable dams. To initiate the sedimentation process, a stretch of 150 m wide should be artificially elevated up to + 1,6 mCD to be able to construct permeable dams.
- At the deepest locations of the breakwater, the original design of the breakwater is used but E-concrete blocks are applied to support habitat for, crabs, shellfish and fish.
- The original phase 2 and 3 are now split so the Bah Bolon river can flow in between:
  - Involuntary resettlement of Kuala Indah village is therefore excluded. Attractive alternative housing (heating, piped water, electricity etc.) is proposed in phase 2 to offer housing for dockworkers (influx of outsiders) and residents of Kuala Indah who are willing to leave their houses.
  - River diversion is therefore partly postponed. One small branch still debouching near Kuala Indah village. The other one is diverted to SE breakwater to supply fresh water and sediments to the downdrift side of the port.
- The dredged material (silty sand) is reused to create the right conditions for mangroves to grow.
- A water treatment plant is added to the master plan to ensure clean (piped) water for the villages nearby and to prevent subsidence because of deep-water subtraction. The port can only be sustainable when industries will be prohibited to extract deep groundwater as a source for fresh water. In Indonesia it is common practice to extract deep ground water resulting in large amounts of settlement up to 10 cm/year in densely populated areas.
- Initiate an education program for local people to make the port-related jobs reachable for the local people. Create a port-museum (owned by local people) like 'Future Land' in the PoR.

In the re-applied evaluation framework presented in [Chapter 6](#), several standards were first indicated with a 'no' and now with a 'yes':

**Standard Improvement**

- 2 The BwN design will probably get more support from the government and therefore creating a bankable business case.
- 6 Before the construction phase starts, multi-objective landscape designs will be shown to the local community and the positive impact will be explained.
- 11 By creating attractive alternative housing (heating, piped water, electricity etc.) voluntary resettlement is more likely to occur.
- 15 By stimulating and planting mangroves NGO's, local communities and nature can also take advantage of the port development (current mangrove forest looks unhealthy on aerial images) so a win-win situation is created.
- 18 A thorough analysis of the ecosystem services is done before designing alternative port lay-outs.
- 19 The present ecosystem is partially conserved and services will probably be restored in the long term: mangroves.
- 22 To prevent subsidence an integrated water supply system (piped water from water treatment plant) is proposed, for industries as well as residents.
- 23 The littoral drift (current) transports sediment which is trapped by the roots of the mangroves or permeable dams, resulting in a stable coast. These ecosystem services are now used in the design of the breakwater.
- 26 The mangrove-based breakwater offers resilience against sea-level rise since the breakwater (mangrove) grows relatively with the sea-level rise.
- 27 The development of the local economy is used for stimulation of the ecosystem (mangroves) and the water supply for the industries will also supply the houses of local people.
- 29 The BwN design philosophy fosters innovation. This resulted in a unique idea to implement mangroves in the breakwater design.
- 30 A master student in Civil Engineering of the TU Delft has done a graduation thesis (8 months) about improving the current master plan resulting in an unbiased advice, so a tie with a University is made.
- 34 The corporate governance is monitored and improved, all involved (international) employees are now up-to-date.
- 36 One of the issues on the political and societal agendas is the shortage of employment in the region. This shortage can now be resolved by providing targeted trainings for local people to work in the port-related companies.

**5.10. Conclusion: general applicability of the BwN solution**

To determine the feasibility of using mangroves as part of the breakwater, a literature study was carried out resulting in a checklist with habitat requirements for mangroves. According to this checklist the site at KT appeared to be suitable (for engineering the conditions) for mangrove establishment. The construction of permeable dams, similar to the coastal protection program in Demak (Java, Indonesia), will result in natural accretion of the breakwater and will create the right conditions for mangroves. This BwN solution requires two main adaptations in the current master plan:

- The dimensions of the breakwater design
- The phasing of the breakwater and adjacent terminals

Looking at the required dimensions (volumes) of the mangrove breakwater for KT, it is recommended to limit the application of a mangrove protection to the first 2000 m (up to -5 m CD) of the SE breakwater. This BwN solution and related consequences for the port development changed the view on the PoKT project and after applying the evaluation framework again, it is concluded that the proposed BwN alternative with the conceptual design of the mangrove breakwater has the potential to meet the international standards treated in Chapter 2.

The checklist for habitat requirements for mangroves resulted in a preliminary design of the mangrove breakwater, which consisted of a mild slope around MSL of muddy soil with permeable dams to retain the sediment and initiate the natural process of accretion. According to the preliminary feasibility study, for deep sea ports like the PoKT this BwN solution will only be

partially applicable since large depths result in large amounts of needed fill material (but if dredged material is used costs are lower). At the moment, after this research came up with this idea, RHDHV (Indonesia) is looking for opportunities to use permeable dams to initiate the natural process of accretion and therefore creating a 'naturally growing' breakwater for a small (marina) port development. It is likely that the mangrove breakwater is better applicable to such (shallow) type of ports where the site conditions meet the habitat requirements for mangroves listed in the checklist of Table 3.

#### **General conclusion about the BwN solution: mangrove breakwater feasibility**

According to the habitat requirements for mangroves it appears to be technically feasible to stimulate the growth of mangroves at KT. However, the application of mangroves as part of the breakwater is (financially) limited to the current mudflats at a maximum depth of -5 mCD. In Figure 59, it can be seen that this is only the case for part 1 and 2. In the case of the PoKT (a deep-sea port) a hard structure for part 3 and part 4 is likely to be unavoidable.

This BwN solution (with Permeable dams and planting mangroves), is better applicable to smaller ports like marina's, where the depth is limited.

In the current design part 3 and 4 are close to the deep trench because headland is not excavated, so breakbulk and container are close to deeper water. If you want to locate the breakwater within the -5 mCD depth contour, the terminals should be located further inland and consequently more dredging needed. But in this preliminary design, the location and orientation of the breakwater is not reconsidered.

According to the BwN guidelines (Ecoshape BwN Guidelines, 2018) several questions need to be answered if a BwN solution (also called ecosystem engineer) is considered to be included in a design for coastal protection or coastal rehabilitation:

- *Is it possible to create a suitable habitat for a specific ecosystem in the project area?*

According to the checklist, the site at KT offers possibilities to create a suitable habitat.

- *What would be the envisaged (protection) services of this ecosystem?*

Protection against waves, so ships (container vessels in the final phase) can be served. Total damping by mangroves or partially by a (smaller) hard breakwater.

- *To what extent can the ecosystem contribute to the primary (protection) function of the design and how does this affect the design itself? For example, what dimensions of a mangrove forest are needed to reduce erosion or stabilize sediment? And what dimensions act as an efficient dissipator of wind and waves?*

Not only wave dampening, but also natural accretion. To realise enough damping (see Table 2 with limited wave heights per ship) the design should be made wider. At least 150 m at MSL.

- *What effects does the ecosystem engineers in this ecosystem have on the existing physical, ecological and socio-economical system?*

See Chapter 3. *Avicennia* spp holds the sediment along the shore and ecologically offers a lot of ecosystem services. Socio-economical they provide ecotourism and for instance provide wood.

- *What are the costs, uncertainties and risks involved with including these ecosystem engineers in the design?*

See 5.5. Cost estimates of the preliminary designs of the mangrove breakwater and 5.8. Risk and benefit assessment of the chosen BwN solution.

# 6 The evaluation framework: standards relevant for international port projects and sustainable development

Financial  
Social  
Environmental  
Governance

Design phase

Operation phase

Standard	Requirement	Chapter 2: Illustrative example for success	Chapter 2: Importance of selecting this requirement	Chapter 3: application of the framework to KT. Is this the case?	Chapter 5: application of the framework to the BwN alternative
<b>FINANCIAL</b>					
1. Expert opinion PoR (2018), Strategy PoRint (2018)	<b>The project generates extra cargo flow to Rotterdam and strengthens the competitive position of the Netherlands.</b>	In 2017 the throughput of PoR rose by 1.3% (to 467.4 million tonnes), mainly because of the growth in container throughput. The market share of Rotterdam in the Hamburg-Le Havre range did fall slightly: from 37.6% to 37.2% in 2017. New partners within the World Port Network will strengthen the competitive position of the Netherlands.	Participation in an international port project creates a strong international foundation to be more resilient if growth and profitability in Rotterdam becomes less impressive in the future. PoR is still leader in the Hamburg-Le Havre range, but world trade is shifting towards the east.	YES, the PoKT will be part of the World Port Network of the PoR strengthening the market share of the PoR in the Hamburg-Le Havre range where other ports are also looking for opportunities to participate in international port projects.	YES, this is still the case.

Standard	Requirement	Chapter 2: Illustrative example for success	Chapter 2: Importance of selecting this requirement	Chapter 3: application of the framework to KT. Is this the case?	Chapter 5: application of the framework to the BwN alternative
2. IFC (2012), Expert opinion PoR (2018), Strategy PoRint (2018)	<b>The project has a positive and solid business case including risk-surcharges. The financial risks are limited to capital in the joint venture.</b>	For instance, when a business case is not bankable without non-commercial financing, governmental support is needed to finance the gap since the project stimulates the national economy. In the long term (e.g. more than 20 years) the port project will be profitable.	Banks typically look at the first 14-20 years of an investment. When payback time is longer than the 20-year horizon, the business case can only be profitable with non-commercial financing.	<b>NO, the current business case shows large CAPEX (mainly quay walls, breakwaters and land reclamation). Non-commercial financing is still needed to fill the gap.</b>	<b>YES, large CAPEX is postponed and the nature enhancement measures are likely to attract governmental support.</b>
3. Expert opinion PoR (2018), Strategy PoRint (2018)	<b>Risks of participating in the project are determined beforehand and are manageable.</b>	In the host country of the project other standards may apply concerning for instance the CO <sub>2</sub> reduction. A risk of participating in such a project is <u>reputation damage</u> . Before investing in the project, measures to manage this risk should be determined.	A risk assessment for participating in an international project needs to be executed (with second opinion) to identify measures to illuminate, mitigate and monitor the risks.	<b>YES, together with the help of the Dutch commission MER and a Dutch engineering company an impact and risk assessment is executed and measures are proposed. No showstoppers are identified.</b>	<b>YES, this is still the case.</b>
4. Expert opinion PoR (2018), Annual Report PoR (2017), IFC (2012)	<b>The project stimulates the national economy of the host country.</b>	In 2016, the added value of the PoR amounted to more than 23 billion euro. That is 3.3% of the Dutch gross domestic product (GDP). This shows the importance of a port to the national economy.	The port boosts the national economy by stimulating import to and export from the country and by creating an attractive climate for multinationals to settle.	<b>YES, the PoKT makes it possible for Indonesia to profit from international trade. The 'Industry Max' scenario can generate up to EURO 3.3 billion 'value added'</b>	<b>YES, this is still the case.</b>

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5. Port Vision 2030, Annual Report PoR (2017), UN-SDG 9 (2018), IFC (2012)	<b>The port lay-out design is fit for the future to allow for future expansion and is adaptive in case of unforeseen scenarios.</b>	When for instance in the 'base' scenario a GDP growth of 4% is expected and in the 'maximum' scenario a GDP growth of 6% is expected, areas should be designated for future expansion according to the 'maximum' scenario.	During the master planning phase of the port project different scenarios should be considered and room for future expansion of the port should be designated to allow for future expansion.	Partially, in the current master plan there is room for adaption when future scenario deviates from the predicted scenarios but for the PoR 3 scenarios were not sufficient to cover all future scenarios.	YES, by postponing river diversion and resettlement of residents, the BwN alternative is more adaptive than the original master plan.
<b>SOCIAL</b>					
6. OECD Guidelines for Multinationals (2011), Expert opinion PoR (2018), Annual Report PoR (2017)	<b>Close co-operation with the local community is encouraged.</b>	For instance, by involving primary schools and sport clubs in the decision-making process, support for the port development is expected. Purchasing goods from local shops, (similar to Sohar project) stimulates co-operation with the local community.	Decision-making may not be primarily driven by economic and functional requirements. At least two local parties needs to be involved in the decision-making process.	NO, transparent dialogue with residents has not started yet, so residents may be concerned about changes in their livelihood. Until now only a brief conversation with the Batubara Authorities and Pelindo 1 has been taken place.	YES, before the construction phase starts, multi-objective landscape designs will be shown to the local community and the positive impact will be explained.
7. IFC, Expert opinion PoR (2018), Annual Report PoR (2017), BwN Guidelines (2018)	<b>Clear stakeholder management is executed starting in the initiation phase.</b>	By cooperating with stakeholders, new opportunities may be identified, and barriers may be solved. Good quality of the dialogue with stakeholders plays an important role.	To prevent opponents of the project, at least one stakeholder meeting with all stakeholders is organised before definitively publishing the final design.	NO, a brief conversation with the Batubara Authorities and Pelindo 1 has been taken place, but (port lay-out) plans were already published before informing all important stakeholders.	Partially, the initiation phase of the current master plan already started without clear stakeholder management (this is irreversible).

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8. UN Global Compact (2015), Annual Report PoR (2017), UN-SDG (2015), OECD Guidelines for Multinationals (2011), IFC-PS 2 (2012)	<b>Human rights (of workers) are supported and protected in doing business.</b>	Recognize that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers (RHDHV ToR ESIA, 2017).	Multinationals pursue the protection of human rights. So this is also important to attract international investors.	NA, cultural changes may arise from an influx of workers from elsewhere in Indonesia with other cultures. Industries located in the port complex must support and protect human rights of their workers.	NA, not part of the scope of this research
9. IFC-PS 2 (2012), UN-SDG 1 (2015), Annual Report PoR (2017)	<b>The project and related activities generate work for the local people.</b>	The PoR has 195,972 employees, that is 2.3% of the total in the Netherlands. This shows the importance of a port in providing jobs.	New terminals and infrastructure will attract companies to settle in the port area. Jobs (and education) should be created for local people.	YES, 90.000 jobs could be created by developing the port (Rebel, 2017), but residents may feel worried if these jobs are reachable for them.	YES, this is still the case.
10. IFC-PS 4 (2012), Port Vision 2030, Annual Report PoR (2017), UN-SDG 3 (2015)	<b>Avoid or minimize the risks and impacts to community health, safety and security that may arise from project related activities.</b>	Attention must be paid to vulnerable groups, for example the people living close to the busy roads connecting.	Large infrastructural projects require an environmental and social risk assessment (with second opinion) to identify measures to illuminate, mitigate and monitor the risks.	YES, a security plan with the local police will be set up to avoid security and safety disturbance and a spatial planning for urbanisation will be set up with Bappeda Community health: By relocating people the social structure of the community is broken up.	YES, but postponing the resettlement may result in residents living close to industries.



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11. IFC-PS 5 (2012), UN-SDG 16 (2015)	<b>No involuntary resettlement is needed to start the project.</b>	Involuntary resettlement refers to both physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets). Resettlement is considered involuntary when affected persons or communities do not have the right to refuse land acquisition or restrictions on land use that result in physical or economic displacement.	Involuntary resettlement is (internationally) not accepted. In case resettlement is needed, offer good alternatives in such way that the resettlement will be voluntary.	<b>NO, in phase 2 and 3 'involuntary' resettlement is still needed, arranged by local land acquisition parties/brokers (not according to int. standards).</b>	<b>YES, by creating attractive alternative housing (heating, piped water, electricity etc.) voluntary resettlement is more likely to occur</b>
12. IFC-PS 7 (2012)	<b>Indigenous people, who are groups with identities that are distinct from mainstream groups in national societies, need to be protected.</b>	Based on the IFC definition, indigenous people have the following characteristics: 1) Self-identification as members of a distinct indigenous cultural group. 2) Collective attachment to geographically distinct habitats or ancestral territories. 3) Customary cultural, economic, social, or political institutions that are separate from those of the mainstream society or culture.	Internationally indigenous people (a distinct social and cultural group) are protected. This requirement needs to be considered to attract multinationals.	NA, there are no indigenous people in or around the project area.	NA

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13. IFC-PS 8 (2012), UNESCO (1972)	<b>The project protects cultural heritage in the course of the project activities.</b>	Recognize the importance of for instance World War monuments or cemeteries (at the site) for current and future generations.	To prevent reputation damage for multinationals, cultural heritage need to be protected.	YES, there are cemeteries and World War 2 bunkers identified in the project area. Consultation with local archaeological and cultural office is planned to assess the importance of this cultural heritage.	YES, this is still the case.
14. EHS-IFC (2012), Expert opinion PoR (2018)	<b>Hazardous materials storage and handling facilities should be constructed away from traffic zones and should include protective mechanisms to protect storage areas from vehicle accidents.</b>	This can be done by for example (physical separation) reinforced posts, concrete barriers etc. Hazardous material storage must be isolated from other port activities.	To ensure safety for all people working in the port or living close to the port.	YES, resettlement of residents (of Kuala Indah village) has the advantage that people will not live close to industries where hazardous materials are stored.	YES, a buffer zone (green area) is created between Kuala Indah village and the industries.
15. BwN Guidelines (2018)	<b>The design focuses on opportunities to create a win-win situation for stakeholders as well as for nature.</b>	For applying the BwN philosophy, a starting point is to find out what (contemporary) issues, problems and challenges are on the political and societal agendas.	The local society and government will be supportive when the BwN solution solves one of the local issues or issues arising from the project. Win-win situations should be identified to call the design a BwN design.	NO, the design focuses on the economic and functional requirements and requirements of the government of Indonesia.	YES, by stimulating and planting mangroves NGO's, local communities and nature can also take advantage of the port development (current mangrove forest looks un-healthy on aerial images).

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<b>ENVIRONMENTAL</b>					
16. Port Vision 2030, Annual Report PoR (2017), Expert opinion PoR (2018), UN-SDG 13 (2015)	<b>The project is sustainable according to the Paris Agreement to combat climate change.</b>	A project is generally accepted to be sustainable when for instance nature is enhanced (by planting trees) is stimulated or/and when industries reduce their emission and take them into account in the business case.	The Netherlands as well as Indonesia are aligned to the Paris Agreement to combat climate change by keeping a global temperature rise this century below 2 degrees Celsius and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.	YES, Indonesia is also aligned to the Paris Agreement (for this country the goals are less stringent than western countries).	YES, this is still the case.
17. IFC-EHS (2017) IFC-PS 6 (2012), Convention on Biological Diversity (2010), UN-SDG 14,15 (2015), BwN Guidelines (2018)	<b>Biodiversity needs to be protected and conserved by maintaining ecosystem services.</b>	Especially endangered flora and fauna needs to be protected and conserved, for example forests where migrating birds breed.	To assess the impact of the project, all ecosystem services should be identified. The ecosystem service should be conserved to protect biodiversity.	NO, part of a mangrove forest which is designated as a protected area (Important Bird Area) must be cut down. This area contains valuable biodiversity.	NO, new ecosystem services are created but most of the existing biodiversity is affected by the onshore port development.
18. BwN Guidelines (2018)	<b>The ecosystem services provided by the system are identified before the design phase is initiated and possible new ecosystem services are explored.</b>	Ecosystem services can be provisioning, regulating, cultural and supporting of nature. Assessing the value of the system without intervention. All present ecosystem services need to be identified.	To incorporate the BwN philosophy. In this way the natural system is clear and natural processes may be used in the design.	NO, only a few ecosystem services are mentioned in the ESIA of the master plan.	YES, a thorough analysis of the ecosystem services is done before designing the alternative port layout.

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19. BwN Guidelines (2018) UN-SDG 14,15 (2015)	<b>The present ecosystem is conserved or restored where needed.</b>	When for instance mangrove areas are already present, try to conserve them.	To incorporate the BwN philosophy. Support of the local community is expected.	NO, in the ESIA as compensation measure a replanting program is proposed but not in detail.	YES, partially conserved and services will probably be restored in the long term: mangroves
20. EHS-IFC (2012), Expert opinion PoR (2018), BwN guidelines (2018)	<b>Projects should conduct a risk assessment for dredging activities as part of the development of a Dredging Management Plan.</b>	The Dredging Management Plan should be tailored to the project and should define the dredging methodology; identify and assess dredged materials disposal options and sites; characterize the chemical and physical composition and behaviour of the sediments to be dredged; characterize the environmental baseline where the port will be located.	Large infrastructural projects require a risk assessment to identify measures to illuminate, mitigate and monitor the risks.	NO, this dredging management plan is not yet executed. The behaviour of the mud/silt to be dredged is still unknown which may result in high maintenance dredging costs.	NO, but as part of the dredging methodology re-using the dredged material is proposed.
21. EHS-IFC (2012), UN-SDG 6 (2015)	<b>Impact on water quality, and related management measures, should be considered during the design and siting of port facilities.</b>	An increase in turbidity via suspension of sediment in the water column (or pollutants) can have adverse impacts on aquatic flora, fauna, and human health. Rainwater drainage is needed to avoid draining spoiled water in the sea.	Since water management at other ports in Indonesia (Semarang) was not considered properly, it is important to closely monitor this requirement.	YES, the impact of, for instance, dumping cooling water at the port is mentioned and a threshold regulation and monitoring management are proposed.	YES, this is still the case.

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22. IFC-PS 3 (2012), UN-SDG 12 (2015)	<b>Prevent pollution to air, water, and land. Consume finite resources responsibly in a manner that it will not threaten people and the environment at a local, regional and global level.</b>	Negative external effects are also considered (in costs calculations). Waste/pollution must be treated in a responsible way and not dumped into the sea, land or burned into the air. Besides, prevent deep water abstraction as a source of fresh water. The resulting subsidence will threaten people and environment at a local level.	In Indonesia a lot of polluting old cars and motorcycles pollute the air, plastic is dumped into the water and drinking water is pumped out of the land without restrictions. This mindset needs to be changed.	<b>NO, In the current master plan no integrated water supply system is included. Like generally applicable in Indonesia the industries located at the port area will probably abstract deep ground water. This will result in subsidence like happened at the port of Semarang (Indonesia)</b>	<b>YES, to prevent subsidence an integrated water supply system (piped water from water treatment plant) is proposed, for industries as well as residents.</b>
23. BwN Guidelines (2018)	<b>Natural processes are not only complied with but are also used and stimulated so that infrastructure fits sustainably within the natural environment.</b>	Rapid societal and environmental changes make sustainability and adaptability increasingly important in infrastructural projects. BwN attempts to meet society's needs for infrastructural functionality, and to create room for nature development at the same time.	Identify the processes and related functions present in the system. Using the natural processes would result in a more efficient (financially more attractive) design.	<b>NO, the natural processes are not used in the design.</b>	<b>YES, the littoral drift (current) transports sediment which is trapped by the roots of the mangroves or permeable dams, resulting in a stable coast. These functions are used in the design of the breakwater.</b>

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24. EHS-IFC (2012), Convention on Biological Diversity (2010), UN-SDG 14 (2015), BwN Guidelines (2018)	<b>Areas of high biodiversity value and/or areas used by aquatic life for feeding and breeding and as migration routes should be identified and protected.</b>	If migratory fish are present in river deltas at the location of the project, this location should be protected or nearby locations should be assigned as breeding places by for example prohibiting fisherman to enter a certain area.	Disturbed feeding and breeding areas will not only result in a mortality of aquatic life, but also a major impact on the biodiversity.	Partially, these areas are identified, but project is still partly planned in these areas (not protected) and no other areas are assigned as breeding and feeding areas for aquatic life.	Partially, these areas are identified, but project is still partly planned in these areas (not protected). However, new areas around the breakwater are prepared as breeding and feeding areas for aquatic life.
25. UN-SDG 14,15 (2015), IFC (2012)	<b>Prevent permanent (adverse) negative impact on the river and coastal system.</b>	As part of the design and siting of port facilities, surveys, assessment and modelling of metocean, hydrological, sedimentological and coastal geomorphological conditions should be carried out together with an identification of potential adverse impacts on coastal processes such as erosion and accretion, from the placement of new physical structures. (World Bank Group, 2017)	The development of a port can initiate adverse (erosion) processes on the coastal system and the diversion of a river can have major impact upstream. Consequently, these interventions affect the biodiversity resulting in even more negative impact.	NO, already in phase 2/3 of the current master plan, the river will be diverted and will have permanent impact on river and coastal system. Besides mangroves are cut, so possible risk of coastal erosion. However, according to Royal HaskoningDHV Indonesia (RHDHV, 2017d) it is estimated that the planned construction will not lead to excessive coastline instability risks or to large coastline changes within a short period of time.	NO, there is still permanent impact on the river and coastal system but river diversion is postponed, and the mangrove breakwater can adapt in a changing coastal system.

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<p>26. EHS-IFC (2012), Port Vision 2030, Annual Report PoR (2017), Expert opinion PoR (2018)</p>	<p><b>Future climate change-related impacts and the development of adaptation measures to enhance resilience should be assessed in the design phase of the port project, to allow for the identification, analysis, and evaluation of climate change vulnerabilities and risks.</b></p>	<p>Make designs for different future scenarios regarding climate change, considering sea-level rise scenarios and periods of extreme weather resulting in a fresh water surplus or shortages.</p>	<p>Climate is changing resulting in different physical conditions on the longer term. When the current design is only based on the current conditions, the port will not be fit for the future.</p>	<p><b>NO, there are no adaptation measures included in the master plan to enhance resilience against climate change related impacts.</b></p>	<p><b>YES, the mangrove-based breakwater offers resilience against sea-level rise since the breakwater (mangrove) grows relatively with the sea-level rise.</b></p>
<p>27. Convention on Biological Diversity (2010), UN-SDG 12 (2015)</p>	<p><b>Enhance the benefits from biodiversity and ecosystem services to all.</b></p>	<p>Ecosystems (like coastal protection, water regulation, providing wood, providing food) that provide essential services, including services related to water must be shared equally according to the “Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization”.</p>	<p>Natural resources must be equally shared. No stakeholders must be disadvantaged otherwise opposition against the project is likely to be expected.</p>	<p><b>NO, the benefits provided by the current river and coastal system to the local people are taken away and used for the port development.</b></p>	<p><b>YES, the development of the local economy is used for stimulation of the ecosystem (mangroves) and the water supply for the industries will also supply the houses of local people.</b></p>

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28. UN-SDG 7 (2015), Port Vision 2030, Annual Report PoR (2017), OECD Guidelines for Multinationals (2011)	<b>The port is developed in a sustainable way by stimulating renewable energy.</b>	For instance, supplying the port with 'green' wind energy or by using solar panels.	The awareness of the consequences of using fossil energy is internationally growing. Multinationals benefit if they can show that they are not only reliable of fossil energy.	<b>NO, in Indonesia there is still no drive for developing renewable energy.</b>	NA, the port project is developed in a sustainable way but not regarding the reduction of emissions (this is not the scope of this research).
29. UN-SDG 9 (2018), Annual Report PoR (2017), Port Vision 2030	<b>Build resilient infrastructure, promote sustainable industrialization and foster innovation</b>	Design infrastructure in such a way that industries can share the roads and other utilities together. Innovative solutions should be supported.	Innovation leads to a new mindset and therefore new innovative results.	<b>Partially, the industrial complex creates efficiently infrastructure but sustainable industrialisation is not promoted.</b>	<b>YES, the BwN design philosophy fosters innovation. This resulted in a unique idea to implement mangroves in the breakwater design (which is never done before).</b>
<b>GOVERNANCE</b>					
30. OECD Guidelines for Multinationals (2011), Expert opinion PoR, (2018) Annual Report PoR (2017)	<b>Develop ties with local universities, public research institutions, and participate in co-operative research projects with local industry or industry associations to generate knowledge and skills.</b>	For instance, hiring graduate interns from the University of Technology Delft will give new insight in the way to approach the project.	Develop ties with the local industry to share knowledge about current port activities. This will help to create a suitable design that fits within the environment.	<b>NO, there are still no ties with local universities or the local industry associations to generate knowledge about the current port activities.</b>	<b>YES, a master student in Civil Engineering of the TU Delft has done a graduation thesis (8 months) about improving the current master plan resulting in an unbiased advice.</b>



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31. OECD Guidelines for Multinationals (2011), Expert opinion PoR (2018), Annual Report PoR (2017), Strategy PoRint (2018)	<b>Abstain from any improper involvement in local political activities. Local political stability is needed.</b>	Nepotism is discouraged, and bribery/corruption is out of the question.	Political instability will lead to project delays and will not attract multinationals.	<b>NO, local political activities show signs of nepotism (in land acquisition activities). Important to note: PoR is not involved in these activities.</b>	<b>NO, political situation still the same.</b>
32. OECD Guidelines for Multinationals (2011), UN-SDG 17 (2015), Annual Report PoR (2017)	<b>Contribute to the development of environmentally meaningful and economically efficient public policy.</b>	For example, by means of partnerships or initiatives that will enhance environmental awareness and protection.	Environmental awareness is internationally growing and needs to be adopted in public policy.	<b>YES, the involvement of PoR can work as a “force for good” regarding the Indonesian decision making and public policy.</b>	<b>YES, the mangrove breakwater contributes to the development of environmentally and economically efficient public policy.</b>
33. IFC-PS 1 (2012), Expert opinion PoR (2018)	<b>Within a social and environmental assessment, the negative and positive impact of feasible alternatives is identified.</b>	For several port layout alternatives the ESIA is executed resulting in insight in negative impact of the alternatives as well as positive impact. This is characterised as the traditional approach in designing infrastructural works.	An ESIA is necessary to identify the risks and propose mitigation and or compensation measures to reduce these risks/impact.	<b>YES, but the focus in the feasibility study lies on mitigating and compensating negative impact. (41 negative versus 6 positive impacts identified)</b>	<b>YES, now the ESIA is executed parallel to the design process instead of afterwards resulting in more positive impact.</b>

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34. OECD Guidelines for Multinationals (2011), Annual Report PoR (2017), Strategy PoRint (2018)	<b>Support and uphold good corporate governance principles and develop and apply good corporate governance practices, including throughout enterprise groups.</b>	The employees of the PoR working at the office in Indonesia should pursue the published vision of the PoR and should work according to the Code of Conduct of the PoR.	Because multinationals operate in different countries with (employees with) different cultures and standards, all employees need to be aware of the vision of the company they work for.	NO, as part of this research the corporate governance of the PoR was checked. Some experts working for the PoR where not yet completely up-to-date about the new published vision of the PoR.	YES, since the corporate governance is monitored and improved where needed, all involved employees are now up-to-date
35. EHS-IFC (2012), Annual Report PoR (2017), Expert opinion PoR (2018), UN-SDG 16 (2015)	<b>The project is executed according to the host countries rules and regulations.</b>	When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent standards or measures than provided in the IFC guidelines are appropriate, in view of specific project circumstances, a justification is needed which should demonstrate that the choice is protective for human health and the environment.	The rules and regulations of the host country may differ from the generally used standards, so conflicts need to be prevented.	YES, as stated in the CSR-statement of PoR all activities comply with the Indonesian rules and regulations.	YES, still the case.

Standard	Requirement	Chapter 2: Illustrative example for success	Chapter 2: Importance of selecting this requirement	Chapter 3: application of the framework to KT. Is this the case?	Chapter 5: application of the framework to the BwN alternative
36. BwN Guidelines (2018)	<b>Connect to political and societal agendas to get support for the BwN design.</b>	A starting point for applying BwN is to find out what (contemporary) issues, problem and challenges are on the political and societal agendas. The local society and government will be supportive when the BwN solution solves one of these local issues for instance solving a flood protection issue in a village nearby.	Political support will prevent project delays and strengthens the connection with the local community and political bodies	<b>NO, the approach of the current master plan is conventional so no BwN solutions are included and the only link to the political agenda is related to the need for economic development.</b>	<b>YES, one of the issues on the political and societal agendas is the shortage of employment in the region. This shortage can be resolved by providing targeted trainings for local people to work in the port-related companies.</b>

First NO:	2, 6, 7, 11, 15, 17, 18, 19, 20, 22, 23, 25, 26, 27, 28, 30, 31, 34, 36
Now NO:	17, 20, 25, 31
First NO, now YES:	2, 6, 11, 15, 18, 19, 22, 23, 26, 27, 29, 30, 34, 36
First YES, now YES:	1, 3, 4, 9, 10, 13, 14, 16, 21, 32, 33, 35



# 7 Conclusions and recommendations

Due to financial and political reasons, no final design for the PoKT has been created yet. This provided the opportunity to study and apply the BwN design philosophy in an early stage of the design process to improve the current master plan. Reconsidering the PoKT project from a different point of view resulted in case-specific recommendations for the PoKT and recommendations for the general applicability of the proposed BwN solution: a mangrove breakwater.

## 7.1. Conclusions

By designing a port-layout in which nature enhancing opportunities are included and natural processes are used, the realisation of a port development project such as the PoKT project becomes more likely. Not only because of the improved legal and local political support but also to create partnerships with international companies which support sustainable development. The goal of the Indonesian government is in line with this approach, since five ports in Indonesia are selected to be developed as deep sea international 'port hubs' which need to attract international clients. To create this world-class port, the port development needs to meet the applicable international standards and functional requirements. To improve the current master plan of the PoKT, so that the port development fits sustainably within the natural environment (and new opportunities for nature are provided), the following main question is answered:

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**How can opportunities for sustainable port development be identified and the Building with Nature philosophy be applied to ports in Indonesia?**

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This main question is answered by first applying the BwN philosophy to the case of the PoKT, and finally evaluating the general applicability of the proposed BwN solution to other (Indonesian) port development projects. This process is done by answering the following five sub-questions:

**Sub-question 1: Which set of standards and goals apply to international port projects of the PoR and how can these standards and goals in relation to sustainable development be incorporated in an evaluation framework? Answered in Chapter 2.**

To understand the drive for sustainable development and to answer sub-question 2, a desk study into standards and goals and interviews with experts resulted in the following set of standards:

- Port Vision 2030 (2011) and annual progress reports on this vision
- Annual Report of the Port of Rotterdam including the CSR-statement, mission, vision and strategy (2017)
- International strategy of Port of Rotterdam International (2018)
- Expert opinion regarding international businesses of the Port of Rotterdam (2018)
- Dutch Ministry of Foreign Affairs: OESO Guidelines for multinational enterprises (2011)
- IFC's Sustainability Framework (Environmental and Social Sustainability Policy Statement 2012) including the IFC Performance Standards
- IFC's Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals (2017)
- Convention on Biological Diversity describing the Strategic Plan for Biodiversity 2011-2020 (2010)
- UNESCO Convention concerning the protection of the world cultural and natural heritage (1972)
- United Nations Global Compact guide to Corporate Sustainability (2015)
- United Nations Sustainable Development Goals (2015)
- Ecoshape Building with Nature Guidelines (2018)

From these standards, requirements were selected to develop an evaluation framework. This framework is accepted to be fully representative since further literature study into these requirements (on the domain of People, Planet & Profit) started to repeat themselves.

**Sub-question 2: Does the current master plan of Kuala Tanjung meet the vision of the PoR, the international standards and the Building with Nature philosophy and guidelines? Answered in Chapter 3.**

According to the evaluation framework of the previous sub-question, the answer to this question is no. The current master plan of Kuala Tanjung does not yet meet all requirements stated in the evaluation framework of the previous sub-question. It is concluded that the master plan of the PoKT was mainly driven by functional requirements and economic growth. The Environmental and Social Impact Assessment (ESIA) which was conducted after an alternative was selected, proposed several mitigation and compensation measures. One of those compensation measures was drafting a replanting program for mangroves. These measures were not further elaborated upon in the current master plan. According to the ESIA the largest negative impact is caused by the river diversion, resettlement of residents, the influx of outsiders, dredging and reclamation, cutting mangroves, disturbing an Important Bird Area (IBA) and the interface between salt and freshwater and the construction of the breakwater. These opportunities for improvement were identified and kept in mind for answering the next sub-question.

Some important findings of the application of the evaluation framework to the PoKT:

- Standard 2: Business case still has a negative NPV because of major CAPEX (river diversion, breakwaters, and land reclamations).
- Standard 6: There is still a lack of co-operation with the local community.
- Standard 22: There is no integrated water supply system is included in the master plan. This will probably result in subsidence like happened at the port of Semarang (Indonesia).
- Standard 26: There are no adaptation measures included in the master plan to enhance resilience against climate change related impacts.
- Standard 33: ESIA also needs to focus on the positive impact (now: 41 negative versus 6 positive). The ESIA should be conducted parallel to the design process of the alternatives to identify win-win solutions.
- Standard 34: In doing international business good corporate governance of the PoR is needed but there is still room for improvement of the corporate governance.
- The PoKT project does not meet any of the standards regarding the BwN philosophy. The PoKT project is a traditional port development project driven by economic growth.

**Sub-question 3: How can the current master plan of Kuala Tanjung be improved by applying the Building with Nature design philosophy? Answered in Chapter 4.**

According to the BwN design philosophy, a better understanding of the physical and ecological system is needed to identify the ecosystem services. These ecosystem services are provided by the system without intervention where nature and society benefit from. It was concluded that several key ecosystem services were provided by the presence of mangroves:

- Providing habitat of marine fish larva and local/migrating birds
- Removing nutrients and thus providing fresh water
- Providing timber and charcoal for cooking
- Protecting the coast by preventing erosion and capturing sediments
- Regulating atmospheric carbon dioxide levels by carbon sequestration
- Stimulating eco-tourism by creating aesthetic value

From the previous sub-question, it was concluded that the construction of the breakwater had a large (irreversible) impact on the coastal system and furthermore formed a large part of the CAPEX. However, despite the moderate wave climate at the Strait of Malacca, the goal of creating a world-class container hub (24/7 operations) implied the need for a breakwater. Since mangroves serve as a coastal protection by attenuating waves in large parts of Indonesia, it was proposed (with expert reviews) to include mangroves as part of the breakwater design: an onshore alternative with a mangrove breakwater. In addition, an important functional requirement of the PoKT is 'hinterland connections' which makes an onshore alternative functionally attractive.

**Sub-question 4: Which considerations are required in the current master plan in order to implement the proposed Building with Nature solution and what are the implementation risks? Answered in Chapter 5.**

In order to determine the feasibility of using mangroves as part of the breakwater, a literature study was carried out resulting in a checklist with habitat requirements for mangroves. According to this checklist the site at KT appeared to be suitable (for engineering the conditions) for mangrove establishment. The construction of permeable dams, similar to the coastal protection program in Demak (Java, Indonesia), will result in natural accretion of the breakwater and will create the right conditions for mangroves. This BwN solution requires two main adaptations in the current master plan:

- The dimensions of the breakwater design
- The phasing of the breakwater and adjacent terminals

Looking at the required dimensions (volumes) of the mangrove breakwater for KT, it is recommended to limit the application of a mangrove protection to the first 2000 m (up to -5 m CD) of the SE breakwater. This BwN solution and related consequences for the port development changed the view on the PoKT project and after applying the evaluation framework again, it is concluded that the proposed BwN alternative with the conceptual design of the mangrove breakwater has the potential to meet the international standards treated in chapter 2. Nevertheless, some implementation risks are:

- The growth of mangroves can fail as a result of numerous factors
- During storm events and/or high waves occurring the permeable dams may fail
- The mangrove-based protection is still in its infancy: more pilots are needed

**Sub-question 5: Under which conditions will this Building with Nature solution be applicable to other ports in Indonesia? Answered in Chapter 5.**

A checklist for habitat requirements for mangroves resulted in a preliminary design of the mangrove breakwater, which consisted of a mild slope around MSL of muddy soil with permeable dams to retain the sediment and initiate the natural process of accretion. According to the preliminary feasibility study, for deep sea ports like the PoKT this BwN solution will only be partially applicable since large depths result in large amounts of needed fill material (but if dredged material is used costs are lower). At the moment, RHDHV (Indonesia) is looking for opportunities to use permeable dams to initiate the natural process of accretion and therefore creating a 'naturally growing' breakwater for a small (marina) port development. It is likely that the mangrove breakwater is better applicable to such (shallow) type of ports where the site conditions meet the habitat requirements for mangroves listed in the checklist of sub-question 4.

### Main conclusions

In this research the BwN philosophy provided the expected guidance to identify opportunities for sustainable port development of the PoKT. This resulted in a BwN solution for the breakwaters:

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Instead of a traditional 'hard' breakwater, a breakwater is proposed with a mild slope of dredged material around MSL which 'grows' naturally by accretion behind permeable dams creating the right conditions for mangrove trees to establish. This mangrove protection can develop into a sustainable barrier which grows with (relative) sea level rise by trapping sediments.

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A large part of the 17.000 islands of Indonesia are protected from the sea by mangroves which attenuate the waves and can trap sediments. However, at least 35% of the world's mangroves have already been lost in the past two decades<sup>14</sup>. This underlines the relevance of protecting and

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<sup>14</sup> Valiela, I., Bowen, J. L., & York, J. K. (2001). Mangrove Forests: One of the World's Threatened Major Tropical Environments: At least 35% of the area of mangrove forests has been lost in the past two decades, losses that exceed those for tropical rain forests and coral reefs, two other well-known threatened environments. *Bioscience*, 51(10), 807-815.

stimulating mangroves. If all 24 port developments announced by the Indonesian government (President Joko Widodo – APEC Summit, 2014) will consider incorporating mangroves in the port development project this will contribute to the United Nations Sustainable Development Goals.

### Prerequisites to success

The key lessons learnt from this research are that a combination of a thorough understanding of the physical, socio-economic and governmental system and early stakeholder involvement results in higher vital benefits, reduces costs and provides the setting for sustainable design solutions.

### Other port development projects in Indonesia

The aim of the checklist of sub-question 5 is to provide an indication of whether mangroves can be considered as an ecosystem service for a BwN design at a site. Ideally, this is checked in an early stage of the design process in such a way that an optimal habitat for mangroves is created. Later in the design process, the possibilities for adaptation of the design will decrease as design choices have become final and cannot be changed anymore. Yet, the possibility to incorporate mangroves in the final design can be considered at a later stage (using the checklist).

## 7.2. Recommendations

The recommendations are divided into case-specific recommendations and recommendations for the proposed BwN solution. Several recommendations for the PoKT are confirmed by colleagues of the PoR and other people involved in this project [Appendix F](#). These same experts asked for a preliminary feasibility study of the mangrove breakwater, because, if feasible, more wave damping is expected (compared to hard structures), a new business case is created by re-using the dredged material and nature is enhanced.

### 7.2.1 Recommendations: the PoKT port development

- **Closer co-operation with local industries:** initiate discussion-sessions with the industries already using jetties at KT to get a better understanding of the approach of ships and experience with extreme wetter conditions. What is the procedure when ships are moored during high waves? What is the actual downtime in a year of operations? This helps to substantiate the need for breakwaters.
- **Better understanding of the muddy system:** a muddy system reacts differently than a sandy system. For the current master plan the littoral drift is measured (during dry season!) but in a muddy system the cross-shore sediment transport (ebb and flood) is important to understand. A dredged basin can easily turn into a sediment trap resulting in high maintenance costs. Mud characteristics need to be added in the morpho-dynamic model.
- **Identify sources of coarse material (sand):** large land reclamations need to be avoided since there are still no sources of sand identified nearby.
- **Closer co-operating with local community:** early stakeholder management will prevent unforeseen opponents of the project. Connect to (local) political and societal agendas to get support for the port development. Site visits will initiate the dialogue with the local community who has more specific knowledge about the local area. Involve a local party which is responsible for the maintenance (of infrastructure) for a certain period.
- **Use “short tension” mooring to limit downtime in first phases:** KT is not protected by a natural island or natural conditions (wide deep river). In the long-term protection by a breakwater is needed for creating the container terminal, but in the short-term development of exposed berths is accepted with short tension to limit the downtime.
- **Better understanding of the impact of the river diversion:** for the river diversion a calculation (SOBEK model) should be made to determine the length of the channel such that the backwater effect in the upstream river part is minimised.
- **Clarify the benchmark for the z-axis:** in the current master plan the reference levels for the vertical dimensions of the geotechnical measurements (boreholes) differ from the reference level used for the cost estimates of, for instance the breakwater. Detailed bed level measurements are needed and subsidence needs to be monitored/integrated.
- **Make unit prices used for the CAPEX more precise:** these unit prices are still inaccurate since there is still no possible source for coarse material identified.



#### Assumptions and notes:

- In particular the standards of the PoR and associated institutes were taken into account in creating the evaluation framework.
- The focus in reconsidering the PoKT project was on the ‘environmental standards’ and the mismatches with the BwN philosophy.
- It was assumed that a BwN solution which will have multiple benefits (for stakeholders), gets governmental support and therefore will be easier to finance.
- A conceptual spatial design was created based on maps, aerial images and reports of preliminary field measurements done for the original PoKT development plan.
- The BwN solution still has uncertainties in port planning and the robustness of a master plan but the focus of this research lied on the technical feasibility of the BwN solution.

### 7.2.2 Recommendations: further research into the mangrove breakwater

A preliminary design is made based on the functional requirements of the PoKT and a checklist for habitat requirements for mangroves. In this design, permeable dams are used to capture sediment and to protect seedlings and juvenile mangrove trees. The following is recommended for further research.

- **Better understanding of the morphological processes:** Morpho-dynamic modelling is needed to understand how the muddy system behaves and what the ideal orientation would be for the breakwater and permeable dams.
- **If natural sediment supply in the system is not sufficient** to let the breakwater naturally grow, (dredged) sediment can be artificially put into suspension. Similar to the BwN project “Mud motor” at Koehool, the currents can then be used to transport the fine sediments in the system to the right place. Agitation dredging, mechanically stirring of the seabed, proposed by Winterwerp (2014) could also be a solution.
- **Wave modelling study** to assess the effect of the bed slope on the incoming waves. For financial reasons (to minimize the needed fill material), the mild slope of the breakwater stops at LAT where coarse material is used to create a steeper slope. The effect of this slope on the incoming waves, needs to be studied in further detail.
- **Detailed geotechnical research** where the terms clay, silts and sands are better defined in grades (in mm). Besides, further research is needed to determine whether the dredged and placed top-layers (or deeper layers) are suitable for mangrove establishment.
- **Study into the influence of outflowing rivers in the system on the salinity** of the seawater and the influence of the breakwaters. A tactical decision has to be made about the location of outflowing rivers.
- **Monitor pollution and nutrient inputs** during construction and the development of terminals because these nutrients increase the biomass above the ground, and reduce the resilience of mangroves to changes.
- **Identify the windows of opportunity** to get better insight in the timeframe wherein the expected rate of success (growth) is the highest. This is the case when the hydrodynamic energy is limited, and seeds are supplied by the mature mangrove forests.
- **Feasibility study of replacing mature mangrove trees** from the headland to the breakwater location and identification of suitable mangrove species for the pioneer and middle zone.
- **Study into the type of material used for the permeable dams** (e.g. coatings or not), and especially the type of fill material still needs to be tested in further detail.
- **Additional ecological expertise in the field of mangroves is needed** to fully assess the suitability for a mangrove replanting program.
- **Further study into the needed amount of wave reduction** to tune the breakwater design and the orientations of the permeable dams with the amount of wave reduction needed for certain ships resulting in a suitable width of the breakwater (set clear goals).
- **More detailed cost estimation** where the CAPEX of the permeable dams are included (100 euro/meter) and where the maintenance costs are also taken into account.

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# Key abbreviations

<b>BwN</b>	Building with Nature
<b>PoR</b>	Port of Rotterdam
<b>PoKT</b>	Port of Kuala Tanjung
<b>KT</b>	Kuala Tanjung
<b>RHDHV</b>	Royal HaskoningDHV
<b>UN-SDG</b>	United Nations Sustainable Development Goals
<b>ToR ESIA</b>	Terms of Reference for Environmental & Social Impact Assessment
<b>IBA</b>	Important Bird Area
<b>mCD</b>	meters above Chart Datum
<b>HAT</b>	Highest Astronomical Tide
<b>MHWS</b>	Mean High Water Springs
<b>MHWN</b>	Mean High Water Neaps
<b>MSL</b>	Mean Sea Level
<b>MLWN</b>	Mean Low Water Neaps
<b>MLWS</b>	Mean Low Water Springs
<b>LAT</b>	Lowest Astronomical Tide (is Chart Datum)
<b>NE</b>	Northeast
<b>NW</b>	Northwest
<b>SE</b>	Southeast
<b>SW</b>	Southwest

# Appendix



# A Examples of dilemmas arising from international activities

For the PoKT port development “dilemma-trainings” were organised concerning the potential construction of coal fired power plants at the PoKT industrial cluster. Since PoR does not want to stimulate the use of fossil fuels a discussion was initiated with several people from the PoR in Rotterdam and Indonesia. One view on participating in such a project is that it offers opportunities for the PoR to reduce the negative impact on nature and society by making a coal fired power plant more efficient and less polluting than it would be without participation of PoR. Others say that it is not according to the CSR statement to be involved in such polluting projects.

*“After all, during this internal process, it was decided that the coal fired powerplant would be developed outside the port area of Kuala Tanjung so finally, the PoR has not taken a position on this development. In general, it is recognised that the moral and ethical agenda in Europe cannot be fully applied to countries like Indonesia. In countries like this, where for example large communities do not yet have access to electricity this is incorporated in the Paris Agreement. At the same time, the agenda in Europe can also not be neglected. The investments of PoR should contribute to deliver sustainable value and as well as remain acceptable not only locally but also globally.”* (Eric van der Schans, head of Environmental Management PoR)

Not only coal fired power plants forms an issue (CO<sub>2</sub> emission standards) in pursuing the vision of PoR, but also the palm oil industry causes dilemmas. Large banks already encounter problems in financing palm oil industry since several palm oil plantations do not act according to international (sustainable) standards.

Because of a report published by Greenpeace, Wilmar (palm oil industry) announced that it would break ties with a controversial supplier. This supplier burned down large parts of the rainforests at Sumatra to create agricultural land for palm trees. Not only the environmental impact is enormous, also indigenous population living in the rainforest loses their livelihood. In addition, the working conditions on the plantations are often poor and not according to the human rights. Therefore, the banks are initiating discussions with the palm oil companies to stop dealing with controversial suppliers. If not, the bank will stop financing. In this way the banks can have positive influence on the impact of the palm oil industry by participating. During the course of this research the following news regarding responsible international businesses was published:

***Raadsleden Rotterdam kritisch over buitenlandse investeringen Havenbedrijf:***

<https://fd.nl/ondernemen/1271212/raadsleden-rotterdam-kritisch-over-buitenlandse-investeringen-havenbedrijf>

***Avonturen in het buitenland moeten wereldfaam Rotterdamse haven op peil houden:***

[https://fd.nl/economie-politiek/1274249/avonturen-in-het-buitenland-moeten-wereldfaam-rotterdamse-haven-op-peil-houden?utm\\_medium=social&utm\\_source=email&utm\\_campaign=SHR\\_ARTT\\_20181017&utm\\_content=economie-politiek](https://fd.nl/economie-politiek/1274249/avonturen-in-het-buitenland-moeten-wereldfaam-rotterdamse-haven-op-peil-houden?utm_medium=social&utm_source=email&utm_campaign=SHR_ARTT_20181017&utm_content=economie-politiek)

***Baas Rotterdamse haven bezorgd over voortgang klimaatoverleg:***

<https://fd.nl/economie-politiek/1273724/baas-rotterdamse-haven-bezorgd-over-voortgang-klimaatoverleg>

***Milieudefensie start klimaatzaak tegen Shell:***

<https://fd.nl/ondernemen/1248467/milieudefensie-start-klimaatzaak-tegen-shell#>

# B Corporate Governance

## PoR

On the basis the visions and standards mentioned in Chapter 2, the corporate governance of the PoR was tested by conducting an informal opinion poll amongst twenty colleagues at the PoR (International, Environmental Management and Port Development). As standard 34 of the evaluation framework (Chapter 6) prescribes, in doing international business, good corporate governance of the PoR is needed. The reason for this opinion poll was the variety of answers of colleagues to the question: “Why do you think that the PoKT project does yet not meet the international standards?” The follow-up question was often “What are actually our international standards?”. After a study into amongst others the Annual reports, CSR-statement, Port Vision 2030 and the International Strategy published in 2018, the following questions were asked to colleagues followed by an interview with Allard Castelein, CEO of the PoR – in Dutch.

In het CSR-statement Allard Castelein: “*We comply with all applicable laws, rules and regulations wherever we do business*”, maar wat als deze wet en regelgeving botst met de Nederlandse wet en regelgeving of ons CSR-statement tegensprekt zoals in Kuala Tanjung?

“We houden ons altijd aan onze eigen Nederlandse regels, deze regels zien we als een baseline.”

“Het eerste uitgangspunt is dat we ons altijd aan de wet en regelgeving houden van het land waar we zijn.”

“Alle Nederlandse regels gelden ook daar, wanneer iets in Nederland verboden is, is het ook daar verboden. Maar we moeten ons ervan bewust zijn dat we als Nederlands bedrijf niet koloniaal bezig zijn door te zeggen wat goed of fout is.”

“Deze uitspraak kan je ook opvatten als, -we zien onze regels als een minimum-, en daarmee lijkt deze uitspraak op een soort escape om te mogen afwijken van onze eigen standaarden.”

“We moeten doen wat de lokale wet en regelgeving van ons vraagt.”

“In Kuala Tanjung doen we dit eigenlijk niet, aangezien we daar internationale regels en standaarden toepassen. We hebben daar de commissie-MER gevraagd om voor ons de toets te doen.”

Het CSR-statement beschrijft drie hoofdthema's. Welke thema's? Welk thema zou je hieraan willen toevoegen?

“Safe and healthy environment, Climate and energy, People and work.”

“Ik mis echt een thema biodiversiteit, dus meer gespist op dieren.”

Volgens het jaarverslag van 2017 zijn er vier *UN Sustainable Development Goals* het belangrijkste voor PoR. – welke vier UN Sustainable Development Goals zijn voor u het belangrijkste in het werk dat u doet voor PoR. Volgens het jaarverslag: (3, 7, 8, 9)

“7, 8, 9, 13 climate action”

“3, 9, 14 life below water, 15 life on land”

“8, 9, 13 climate action, 17 partnerships for the goals”

“3, 7, 9, 11 sustainable cities and communities”

“3, 6 clean water and sanitation , 9, 13 climate action”

“1 no poverty, 2 good health and well-being, 13 climate action, 16 peace justice and strong institutions”

Waarom is stakeholderbetrokkenheid zo belangrijk? In het jaarverslag staat: door samen te werken met stakeholders kunnen nieuwe kansen worden benut en barrières worden voorkomen.

“Hoe later je stakeholders meeneemt in je plannen, hoe steviger de kritiek.”

“Ook in buitenlandse deelnemingen is dit extreem belangrijk, maar wanneer we werken met lokale partijen is het lastig om ze uit te leggen hoe ze de stakeholders moeten benaderen.”

“Ten eerste omdat wij een maatschappelijke verantwoordelijkheid hebben als bedrijf. Ten tweede omdat het “good business” is – slechte stakeholdermanagement leidt tot tegenstanders van je project. En tegenstanders van je project kunnen je project vertragen.”

“Investeren in strategisch omgevingsmanagement is zeer belangrijk. Dit mag dan wel duur zijn, maar uiteindelijk lever je hierdoor een project op waarmee alle stakeholders tevreden zijn.”

“Zo behaal je het beste resultaat! Het resulteert in een win-win situatie voor zowel de initiatiefnemer als de stakeholders.”

Gezien de verantwoordelijkheid die PoR draagt, onderschrijft PoR “The United Nations Global Compact 2012”, ’s werelds grootste duurzaamheidsinitiatief voor bedrijven. Het doel van de United Nations Global Compact is om een wereldwijde beweging van duurzame bedrijven en belanghebbenden te mobiliseren om de wereld te creëren die we willen. Wat voor een wereld willen we?

“Een schone en welvarende wereld, wij kunnen hieraan werken door de energietransitie te stimuleren.”

“Port developers/planners kunnen vaak niet alles binnen de Visie2030 passen. Het is lastig om deze doelen te realiseren.”

De bedrijfscode beschrijft dat PoR graag zaken doet met partijen die hoge standaarden hanteren met betrekking tot ethisch verantwoord gedrag. De “OESO-guidelines for multinationals” van het ministerie van buitenlandse zaken bieden niet-bindende principes en normen voor verantwoord gedrag in een mondiale context die in overeenstemming zijn met de internationaal erkende wetgeving en normen. Wat zijn kenmerken van verantwoord gedrag in een mondiale context?

“Sociale waarde creëren, niet alleen voor het kantoor in Rotterdam (wat onze missie eigenlijk letterlijk beschrijft), maar ook voor de landen waar we zaken doen. Ik merk dat het nog een uitdaging is voor veel van onze in Rotterdam gevestigde collega’s om onze Indonesische collega’s als volledig gelijken te zien”

Wat zijn de hoofddoelen van PoR? De strategie omschrijft er acht. Welke zie je als de belangrijkste?

“We willen in heel veel de beste zijn..”

“Onze hoofddoelen zijn wel erg breed en niet concreet.”

“We willen onder andere nieuwe markten ontwikkelen, maar deze markten mogen geen ‘foute markten’ zijn.”

“Het belangrijkste doel is het ontwikkelen van nieuwe markten, gezien de energietransitie”

Wat is belangrijker, hernieuwbare energie stimuleren of de fossiele industrie efficiënter en minder vervuילend maken? PoR hanteert een 'en-en' strategie zodat publieke waarde wordt gecreëerd zonder economische waarde kapot te maken. UNSDG (7) "Affordable and clean energy"

"In eerste instantie de bestaande industrie verbeteren door deze efficiënter te maken"

"In westerse landen hebben we het geld om hernieuwbare energie te stimuleren, maar in ontwikkelingslanden kunnen ze geen schone energie veroorloven"

"In deze discussie worden de begrippen 'schone' en 'betaalbare' energie genoemd, maar het begrip 'betrouwbaar' mist"

Wat zijn de eisen en beweegredenen vanuit het Havenbedrijf om deel te nemen aan buitenlandse projecten?

"Investerings moeten winstgevend zijn, de haven van Rotterdam stimuleren en we doen het om een wereldwijd netwerk op te bouwen."

"We nemen alleen deel aan projecten die geen imagoschade opleveren."

"Wanneer een project niet duurzaam is (volgens het Parijs Akkoord) moeten we voorzichtig zijn met investeren."

"Wanneer een project werkgelegenheid creëert en de lokale economie stimuleert, maar we moeten hierbij de Nederlandse standaarden in het hoofd houden."

"Het moet niet in strijd zijn met ons CSR beleid en een zichtbaar voordeel opleveren voor de haven in Rotterdam."

"Waarde creëren voor de aandeelhouders en BV Nederland, kennis delen en ontwikkelen en kansen creëren voor onze medewerkers"

"Een beweegreden is dat we een sterk fundamentele basis nodig hebben voor als groei en winst in Rotterdam niet meer vanzelfsprekend is. Momenteel staan we nog in de top 10 van grootste havens en de nummer 1 in kwaliteit, dus dit is ons moment om te shinen. Alle deuren zijn nu nog geopend voor ons, dit is over 20 jaar misschien niet meer het geval."

Wat vindt u dat er veranderd moet worden aan het huidige master plan?

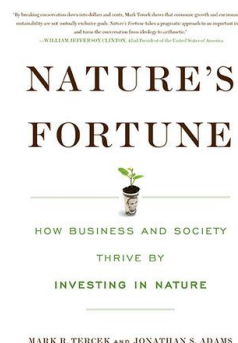
*Het is makkelijk om te zeggen "We doen niet mee aan internationale havenprojecten omdat in dat land/gebied de aanpak niet milieuvriendelijk genoeg is voor het havenbedrijf", maar in dat soort gebieden kan je als Havenbedrijf juist een groot verschil maken en positieve invloed (force for good) hebben. PoR kan juist zijn kennis inbrengen om dit project zo duurzaam mogelijk te maken, wat zonder deze betrokkenheid eventueel niet het geval zou zijn. Dit dilemma speelt ook bij de grootbanken over de palmolie industrie.*

Mijn (auteurs) mening: deelnemen, ook in projecten die er op het eerste gezicht niet aantrekkelijk uitzien.

### Allard Castelein 20-8-2018

BwN = Building with Nature  
KT = Kuala Tanjung (Sumatra, Indonesia)

Het is goed dat je kijkt naar een BwN oplossing voor KT. Allard is zeer geïnteresseerd in BwN aangezien hij in het verleden samen heeft gewerkt met Mark Tercek (CEO van de "Nature Conservancy", een Amerikaanse NGO) waarmee Shell destijds een stuk over Green Infrastructure heeft geschreven. Hierin zijn 50 businesscases omschreven waarbij mangroves, reefs etc. zijn gebruikt. Daarnaast is het boek "Nature's



Fortune” – “How business and society thrive by investing in nature” by Mark R. Tercek and Jonathan S. Adams, zeker het lezen waard.

**Ik: “hoe beoordeelt u of een plan zoals KT interessant is voor het Havenbedrijf om wel of juist niet in te stappen?”**

Bij het beoordelen van een buitenlands havenproject zoals in KT, kijkt hij ook vanuit dit ‘Green Infrastructure’ perspectief. Hij wil het liefste een ‘Net Positive Impact’ zien op verschillende schaalniveaus. Als je ergens een haven gaat bouwen is er altijd impact op zee en land. Neem bijvoorbeeld het havenproject in Brazilië, waar je een hele lange kustlijn hebt waar je maar op één locatie een haven gaat bouwen. Op die locatie verdwijnt er een mooi strand, maar regionaal en nationaal gezien ontwikkel je de economie.

Zo’n havenproject is er om een land te doen ontwikkelen van armoede naar een hogere welvaartsklasse. Bijvoorbeeld, waar een lokale Indonesische bevolking geen energie heeft (en op hout moet koken), zorgen wij dat er weer een energievoorziening komt, zodat ze makkelijker kunnen koken (met licht), en niet ver hoeven te lopen voor hout voor de kachel.

Over het CSR-statement: ook in ontwikkelingslanden gelden onze normen en waarden. Bijvoorbeeld, geen corruptie en goede medische hulp. Dit passen wij toe in het buitenland.

**Ik: “maar ben je dan niet een soort van koloniaal bezig, door onze regels, normen en waarden daar door te drukken?”**

Nee absoluut niet, ik heb een lange tijd in het buitenland gewerkt. Wij hebben een belangrijke rol in zo’n land om de normen en waarden omhoog te halen. Koloniaal handelen is heel wat anders, want wij streven naar geen corruptie, omkoping etc. Je moet je afvragen hoe “volwassen” een samenleving is, dus niet 1 op 1 onze wetten, regels en richtlijnen (CSR) toepassen, maar wel het essentiële van onze normen en waarde.

*Voorbeeld in Oman:* er zijn daar erg veel verkeersdoden. Het was een van de onveiligste landen om te rijden. Toen Shell daar een vestiging had, zijn ze gestart met een “reis-schema-training” om de lokale werknemers te leren rijden en het belang van bijvoorbeeld de gordel uit te leggen. Momenteel is de verkeersveiligheid verbeterd en is het aantal verkeersdoden (onder de lokale werknemers van Shell) afgenomen.

**Ik: “dus wij als Havenbedrijf kunnen juist een positieve invloed hebben op de ontwikkelingen als we deelnemen in dit soort ontwikkelingslanden waar andere normen en waarden gelden?”**

Ja, we moeten ons zeker niet laten afschrikken door de andere normen en waarden die daar gelden. We kunnen in de lokale community juist het niveau omhoog halen door onze technische, sociale (en overige) eisen toe te passen.

In zo’n land is de institutionele capaciteit vaak niet voldoende om besluiten te nemen om een stap omhoog te kunnen maken. Wij als havenbedrijf kunnen een “force for good” zijn als we erbij betrokken zijn.

*Over KT:* ik zie de potentiële kolencentrales niet als een showstopper aangezien in het klimaatakkoord van Parijs staat dat er soepelere regels zijn voor Indonesië. Dat akkoord hebben wij ondertekend en daar (Indonesië) mag je volgens het akkoord de komende jaren meer uitstoten. **Ik: “krijgen we dan niet binnen no-time Greenpeace voor de deur hier in Rotterdam?”** Nee, we handelen volgens de regels en zullen Greenpeace niet voor de deur krijgen.

*Tip:* Laat je niet tegenhouden door dit soort dilemma’s, jij als student moet hier nog volledig voor open staan ondanks dat sommige collega’s hier andere ideeën over hebben.

**Ik: “in het CSR-statement staat dat wij ons houden aan de wet- en regelgeving zoals deze van toepassing is in de landen waar wij werken. Maar wat als dit in strijd is met de internationale standaarden of onze eigen normen en waarden?”**

Ja, we moeten altijd voldoen aan de wetgeving daar waar we werken. Onze standaarden (van het bedrijf) liggen vaak veel hoger dan de lokale standaarden in bijvoorbeeld Indonesië, China, Oman

etc. Deze landen zitten gewoon veel lager op de “development curve” en daarom is het nodig de mondiale dynamiek goed te snappen en ons aan te passen aan de situatie daar.

**Ik: “dus als bijvoorbeeld de aanbestedingsregels anders zijn dan hier, zoals het geval in Brazilië (waar je baggeraars wel al vroeg in het ontwerpproces mag betrekken) en deze dus tegen de Nederlandse regels ingaan, werk je toch op die manier?”**

Ja, ons CSR beleid staat ook voor kwaliteit. Dit willen wij garanderen door Nederlandse partijen in te zetten waarvan wij weten dat de kwaliteit op orde is. Deze baggeraars hebben wij al voor de aanbestedingsfase erbij betrokken (zoals dat daar is toegestaan) en uiteindelijk ook gekozen als aannemer.

**Ik: “maar dat kan toch overkomen alsof je geld naar Nederland aan het schuiven bent, door alleen Nederlandse aannemers een project te gunnen?”**

Nee, uiteindelijk doen we het om de beste kwaliteit te garanderen en houden wij ons aan de lokale wetgeving.

Stel dat we uiteindelijk toch niet deelnemen aan het project in KT, dan hebben we wel wat aan jouw onderzoek aangezien we voorstander zijn van BwN oplossingen en het goed is dat je naar alle internationale standaarden hebt gekeken.

Ik kijk graag nog even naar de resultaten van je Corporate Governance deelonderzoek.  
**(Ik heb Allard Castelein een hard copy gegeven)**

Over twee maanden (30 oktober) kan je langskomen om je BwN ideeën te laten zien. Dan komt Eric van der Schans (hoofd Environmental Management) er ook bij zitten.

#### Allard Castelein and Eric van der Schans 1-11-2018

Allard Castelein gave his permission to share this last interview as part of my thesis. Eric van der Schans will have a look on my final version (especially on the interviews/corporate governance) before handing in the report.

Advice from Allard Castelein:

- Do not focus on the financial aspects of your BwN solution. Look at functionality and advantages.
- Include in your conclusion a list of prerequisites to success.

Allard Castelein; “The BwN philosophy requires a shift in culture within a company. How would you convince (future) colleagues to apply the BwN design philosophy which improves the conventional approach on infrastructural projects?”

The answer of this question is included in the conclusion of this research as a list of prerequisites to success.

# C Stakeholder analysis

## Project organisation:

- Pelindo 1
- PoR

## Other ports: *Marked with an 'N' is not included in the Excel of Arthur Neeteson (POR Indonesia)*

- Port of Singapore Authority (may lose customers)
- Tanjung Pelepas Port Authority (may lose customers)
- Pelindo 2 (IPC) (can make business cooperation with Pelindo 1 and make profit)
- City and port of Laboehanroekoe (20km SE of KT) - **N**
- Port of Belawan, close to Medan (property of Pelindo 1) - **N**

## Companies:

- Pt. Unilever Oleochemical Indonesia (as a neighbouring company, Unilever asks for good and well-connected infrastructure)
- Pt. Wilmar, palm oil industry (as a company situated next to PoKT, Wilmar may lose customers)
- Pt. Inalum terminal, aluminium industry (as a company situated next to PoKT, Wilmar may lose customers)
- Pt. Bakrie, palm oil industry (as an inactive company, Bakrie may benefit from PoKT)
- Sei Mangkei Special Economic Zone (PoKT can be integrated with the industrial area in Sei Mangkei region) (World Bank Group, 2008)
- Owner of palm oil plantation at Suka Ramai - **N**

## Government:

- IFC World Bank Group
- Dutch Embassy
- Otorita Asahan (local government, which could profit from economic growth)
- Camat Sei Suka (district Sei Suka government, will support the project when jobs are created)
- Camat Air Putih (district Air Putih government will support the project when jobs are created)
- Camat Medang Deras, Camat Lima Puluh
- Kepala Desa Kuala Tanjung, Kepala Desa Lalang (Kepala = headman)
- Secretariat, Sei Suka District
- Bupati Batubara (Regent Batubara, wants national and regional economic growth)
- Wakil Bupati Batubara (Deputy regent Batubara, wants national and regional economic growth)
- Bappeda, Local Planning Agency (now very small, just 1 person representing Batubara region) **N**
- BPN Asahan, Asahan Land Authority
- Regency Forestry and Environmental Department
- Ministry of Transport (gives operating license)
- Ministry of State-Owned Enterprise
- Ministry of Environment and Forestry (supportive about IFC implementation in AMDAL) **N**
- Ministry of Trade
- Tourism Ministry
- Ministry of Industry
- Badan Koordinasi Penanaman Modal (Scheme of foreign investment in the area and negative list of foreign investment)
- National BPN, national land authority (the government agency that regulates the ownership of assets, especially land and land status)
- BPKP, Financial and Development Supervisory Agency
- Ministry of Marine affairs and Fisheries - **N**
- Ministry of Foreign affairs - **N**
- Coordinating ministry of Maritime affairs - **N**
- Coordinating ministry of Economic affairs - **N**
- Indonesian Centre for Environmental Law - **N**

## Knowledge institutions

- Lembaga Ilmu Pengetahuan Indonesia
- Universitas Sumatera Utara

## Representative environmental/social

- Both Ends
- Wetlands International
- Birdlife International, a global nature conservation partnership - **N**
- World Wildlife Fund
- Himpunan Nelayan Seluruh Indonesia (HNSI, fishermen organisation)
- Ampera, local NGO (represent people directly impacted by the construction of ports)
- Small resort Pantai (beach) Datuk at Kuala Indah "Eco-tourism" - **N**

# D Other ports at the strait of Malacca

Other ports located at the strait of Malacca are studied to get a better understanding of their location and orientation.

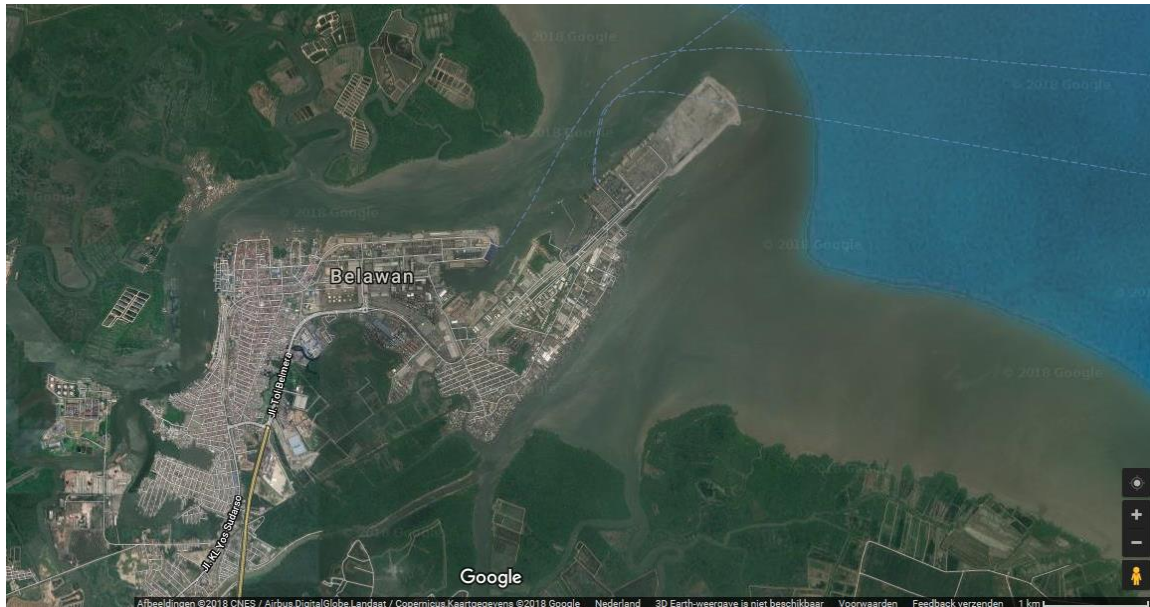


Figure 65 Port of Belawan (Medan, Indonesia) 1 cm is about 1 km

Located NE coast of Sumatra. Indonesia's busiest seaport outside Java. Container terminal (1985), export of rubber, palm oil, tea and coffee. [Container terminal is partly exposed and ships make use of an inland waterway.](#)



Figure 66 Port Klang (Kuala Lumpur, Malaysia) 1 cm is about 1 km

Located at the west coast of Malaysia close to the capital Kuala Lumpur and is the largest port of Malaysia. The 11<sup>th</sup> busiest container port in the world (2012). [Container terminal is protected by a natural island.](#)



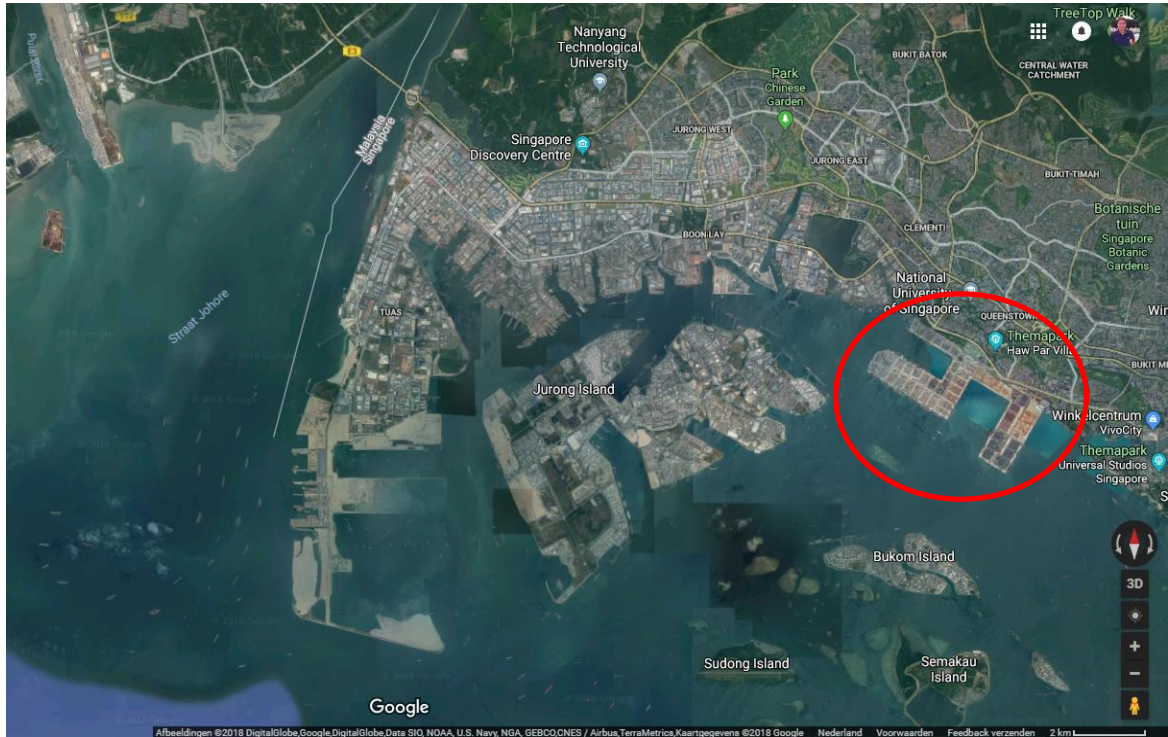


Figure 67 Port of Singapore, 1 cm is about 2 km

Largest port in South-East Asia. The currently used container terminal (red circle) is called Pasir Panjang. Sheltered berths by dredging, offshore terminals made by using caissons surrounding the reclamation.

Brainstorm session PoKT:

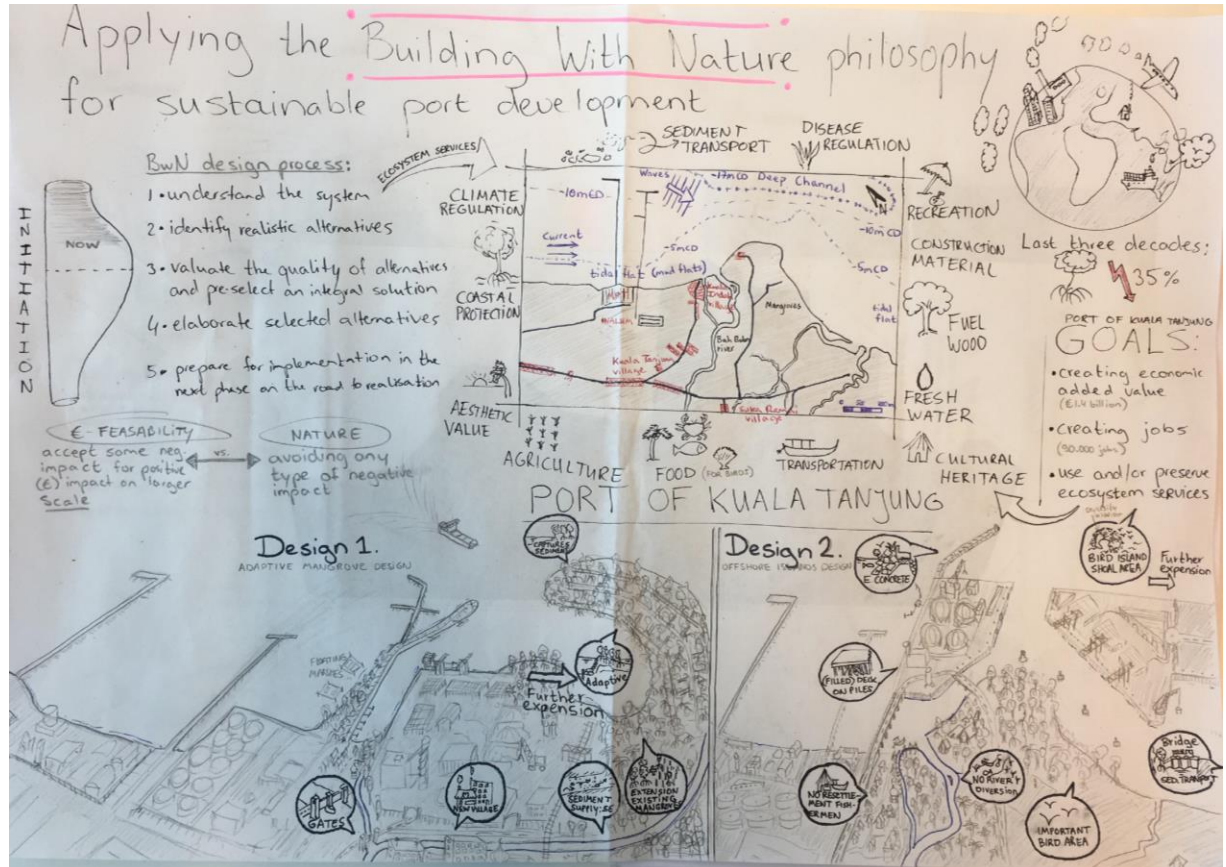


Figure 68 Brainstorm session, design 1 (onshore alternative) and design 2 (offshore alternative)

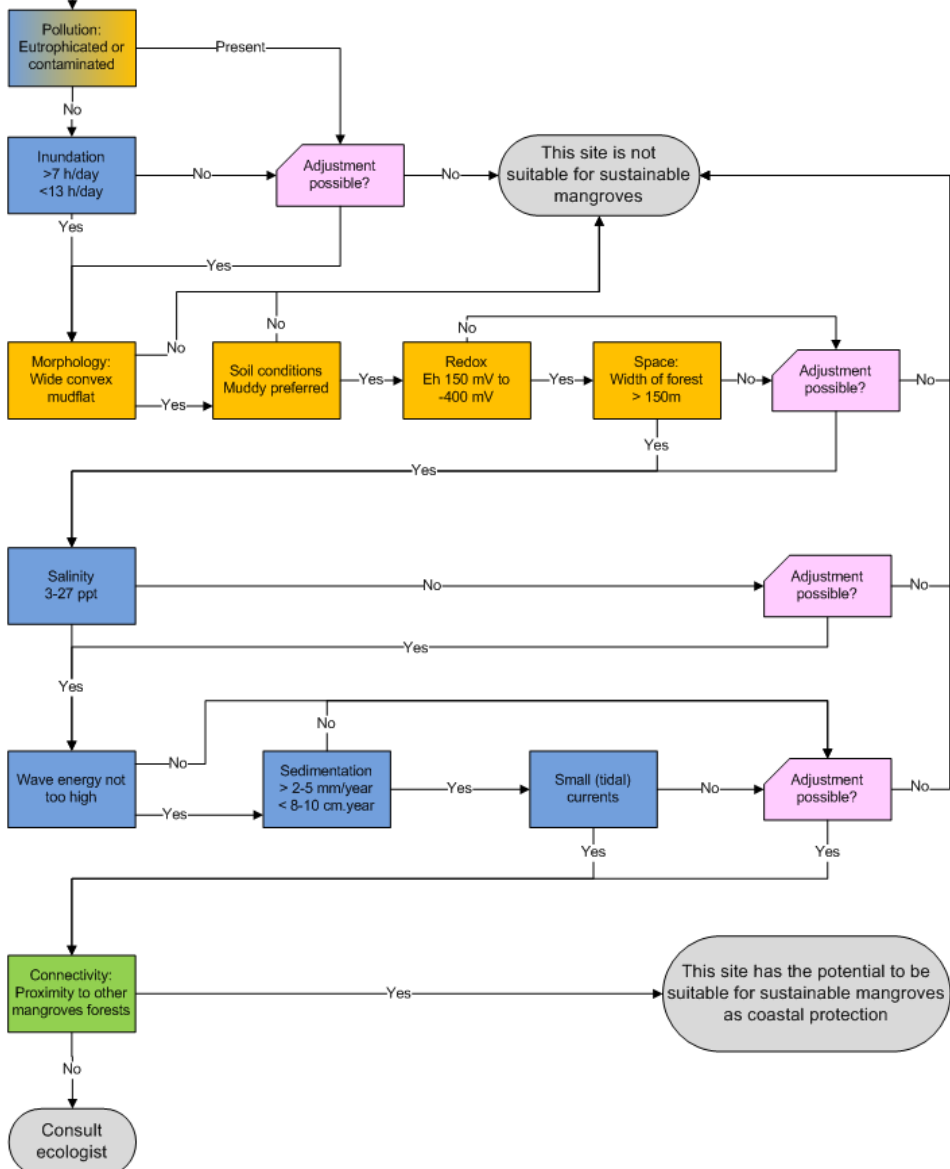
# E Determination flowchart Marine Environment – Mangroves (BwN Guidelines)

(Ecoshape BwN Guidelines, 2018)



Determination flowchart Marine Environment – Mangroves

Coastal Protection



**Legenda**

- Habitat engineering step, Atmosphere
- Habitat engineering step, Lithosphere
- Habitat engineering step, Hydrosphere
- Habitat engineering step, Biosphere
- Adjust / Engineer
- End station

# F Summary of the discussions with supervisors/experts

## **Bregje van Wesenbeeck, Deltares phone call (22-10-2018)**

Bregje: it is good to have an overview of the necessary conditions for mangroves to establish according to literature as boundary conditions for the mangrove breakwater design. Keep in mind that the conditions for mangrove establishment are different than the conditions of the current full-grown mangrove system to survive.

The onshore port development has major impact on the hydrology because the breakwaters will block the outflow of the rivers. A full-grown mangrove forest offers way more ecosystem services than a new developed mangrove forest by people, so try to conserve mangroves instead of compensating. Try to keep it realistic and do not overestimate the value of a newly developed mangrove forest. Look at the report of Marijn Janssen: 'mangrove sensibility analysis'.

When mangroves are cut down and dredging takes place, this can result in CO<sub>2</sub> emissions. Another side-issue is the problem of retaining the soil when mangroves are cut down. Try to focus on the feasibility study of the mangrove-based protection and cost estimate. Is the new business case, where dredged material is reused, more attractive?

## **Tom Wilms, Project Demak Indonesia at Witteveen + Bos (19-10-2018)**

Tom Wilms is involved in the BwN pilot project where brushwood dams are used as a coastal protection in the province of Demak (Java, Indonesia). He sent me the most recent results (Guidelines permeable dams) of this pilot project. One of the results is the ideal distance between the rows of the permeable dams (100x100m, like in the Netherlands) and the type of suitable fill material (brushwood). Since incoming waves during high water damage the back of the structure other fill material like bamboo is suggested. Two requirements for fill material are: the material must be heavier than water; and the material must be durable. Samantha van Hagen is doing her master thesis about this under supervision of Alejandra (PhD). Tom knows Abdul Muhari (Indonesian ministry of maritime and fisheries) and will ask him for the slides he presented at the Ecoshape conference about the failure mechanisms of the brushwood dams at Demak.

About the mangrove breakwater technically: realise that mangroves will grow at MHW for sure, but pioneer species will already grow at MSL. When the conditions for mangroves are right, the plants can grow like weeds. At the deeper parts (-15 mCD or deeper) only conventional 'hard' structures are feasible. Look carefully at the outflow of the rivers, because the location of the outflow (between two structures) determines where sediments will be deposited. Look at the availability of dredged material to use for the breakwater and needed amount of fill material.

Social aspects: when you provide alternative housing for the villagers (fisherman), the distance to shore needs to be limited and preferably close to the mangroves (advantages of mangroves). When piped water supply is created for the industries, also provide the village with clean piped water to create goodwill. Work together with the local people and try to purchase building material and other project related material from local shops/businesses (boosts local economy). New advantage of permeable dams (lesson learned from Demak): mussels will grow/attach on the poles of the permeable dams resulting in more income for the local people collecting shells and mussels.

### **David Dudok van Heel, Royal HaskoningDHV skype meeting (17-10-2018)**

After a short introduction of the progress I have made since the last skype meeting (03-09-18) and the literature study I am doing about mangrove establishment and permeable dams, David told me about a (marina development) project he is involved in at the moment. This port development project is at a much smaller scale than the Kuala Tanjung project, but the site also includes soft-soil conditions. Because of the currents and waves, breakwaters are needed to protect the port basin (but the breakwater costs are very high). The client asks for a cheaper breakwater in the form of a shallow stretch with permeable brushwood barriers which can capture sand naturally instead of a hard structure.

These permeable barriers can capture sand by reducing the currents behind the dams and reducing the wave high. This should result in lower costs compared to the conventional (stone) breakwater. In this case the brushwood dams are not used to stimulate mangroves. David wanted to have a look at the Technical note #4 Permeable Dams (with the latest results of the pilot at Demak) and after permission of Tom Wilms, David got this technical note. David Dudok van Heel said that 85% of the costs of the breakwater are determined by the amount of sand fill so a naturally growing breakwater would be ideal, but mild slopes are needed resulting in a large m<sup>2</sup> footprint and high costs. David advised me to talk with experts of the PoR to discuss the underwater steepness of the breakwater.

### **Alejandra Gijón Mancheño, PhD BioManCO-project (12-9-2018)**

At the moment Alejandra is doing flume experiments to test the effectiveness of the configuration (horizontal, vertical etc.) of the brushwood dams. She is monitoring the hydrodynamics while in the field the morphodynamics are monitored. The goal of the flume experiment is to optimise the structures and to understand the principles behind the way the structures attenuate the waves. The amount of wave attenuation and reflection is measured for the different configurations. This is a scientific approach which takes some time, in Demak (Java Indonesia) the field experiments have already been executed but just with 'trial and error' and not scientific. Advice:

- Create a surface at MSL and ensure that waves are not too high. At Demak the waves are low: SUMMER Hs=5cm and Tp=4-5s, WINTER hs=20cm and Tp=8s. So you need to know how high the waves are.
- The width of the stretch must be determined by an ecologist, but as mentioned in the 'mangrove potential' flowchart a width of 150m is good for a first assumption.

### **Wim Hoebee, PoR harbour master department (6-9-2018)**

After having a look on my ideas for the PoKT, Wim Hoebee comes up with the following advice:

- At the deeper locations the creation of the 'mangrove breakwater' can be very expensive.
- A positive thing of Mangroves could be the damping of the waves, because less reflection (compared to hard structures) is expected in the port basin.
- Soil improvement for the terminals could also be very expensive. Thus, offshore islands could be very expensive.
- Like Ronald Stive said in the meeting of December 2017, postpone the river diversion until the last stage because this action will have major impact and should only be executed when this is really necessary for the port development.
- Is it really necessary to construct a breakwater? The existing (liquid bulk and break bulk) ships can moor at the exposed jetties. Downtime excepted? Answer this question, because the down-time without breakwaters is not calculated for the situation where 'shore tension' is used for the container terminal. In all cases using 'shore tension' is cheaper than breakwaters.
- Positive side of this plan is that you are also compensating for the impact of the terminals.
- It would be very useful to know how Pelindo 1 (current port activities) do when an extreme wave climate occurs. Ship go away to open sea? Or stay moored at the berths? Talk with local parties using the existing jetties.

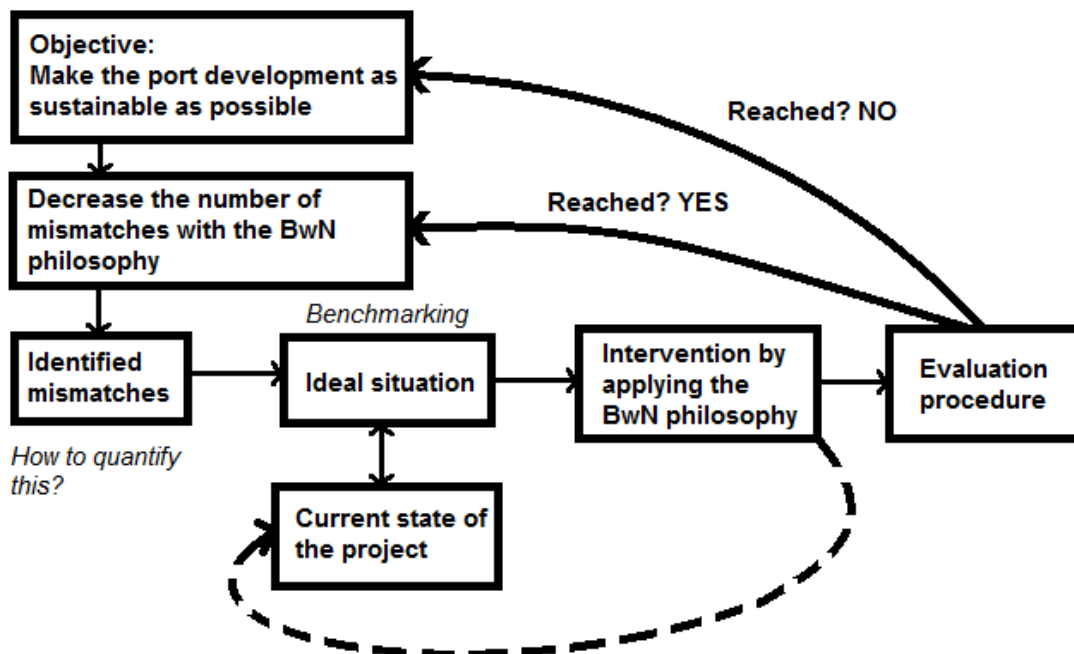
When fine-tuning your design, navigation of ships includes:

- Entering the port, safe mooring
- During (un)loading safe connected to berth
- When leaving, safe mooring

Tugboats can connect safely with ships in a wave climate up to 1.5m. Looking at the wave climate at KT, this should not be a problem.

### Mark van Koningsveld, chair committee (6-9-2018)

This research is using the 'Frame of reference' without explicitly referring to it:



### David Dudok van Heel, Royal HaskoningDHV Skype Call (3-9-2018)

"Het is ook maar de vraag of je wel echt een golfbreker nodig hebt, of dat je een bepaalde downtime accepteert in het ontwerp. (\$) De hoofdgedachte van het ontwerp is echter wel een world-class container transshipment port van KT te maken die kan concurreren met Port Klang (Maleisië), 'Pengadan' en Singapore. Dit is de eerste insteek geweest, vandaar de grote golfbreker om downtime te voorkomen. Hierna is het meer flexibele plan ontstaan waarin bedacht is dat de eerste terminals prima zonder golfbreker kunnen functioneren.

De natuurlijke golfbreker groeit door sedimenttoevoer natuurlijk maar aan 1 kant. De andere kant zal eroderen. Let op dat uit de high level expert review kwam dat sedimentconcentraties in het water relatief laag waren, maar dat deze metingen tijdens het droogseizoen zijn gedaan. Deze metingen kunnen tijdens het regenseizoen veel hoger uitvallen.

De rivieromlegging van de Bah Bolon river is een gigantische operatie die sociale en financiële gevolgen met zich meebrengt. Men zegt dat men bezig is met de landacquisitie, maar niemand is precies op de hoogte in welke mate. Dit is dus een top-risico."

### Arthur Neeteron PoR Indonesia phone call (5-7-2018)

At the moment the KT project does not develop because of political reasons. This makes it interesting for me as a graduate intern to add new ideas which may be considered when the project restarts again. At the moment only national stakeholders are informed well. There is one minister from foreign affairs is a supporter of applying the IFC standards in doing the AMDAL. Local stakeholders are not well informed. Only one 'town hall session' where there was overall support but there are three themes where the residents are concerned about:

- Mangroves and sanitation, also worried about salt intrusion
- Labour for 'their sons' (PoR wanted to look at this but Pelindo 1 said no)
- Land acquisition prices

In addition a field trip (see doc. of HaskoningDHV) and a delegation of Batubara regency government went to Jakarta

Land acquisition seems to be the largest theme because there is no evidence that this process goes according to international standards. See slide 'assessment and summary'. PoR: land acquisition needs to be arranged before we start with the project.

Idea of Arthur is to create a 'Future land' like we have in Rotterdam. Other ideas:

- Resettlement of residents of Kuala Indah and diversion of river can wait 10 years
- Left breakwater also has impact on the coastal morphodynamics (study needed)
- Currently mangrove area is needed for construction in 20 years.

Advantage of this project: when doing nothing, developments will probably continue along the coastline as stand-alone jetties resulting in impact on nature along the whole stretch of coastline. One big integrated port also has the advantage that the utilisation factor will increase since multiple companies can use one jetty. Another advantage is that the ESIA will be lot more detailed than a lot of small ESIA's. Bobby Schijf (NL commission MER) is involved in making the ESIA. Last advice: be positive, because the project will create a lot of jobs. People in NL only see the impact on the mangroves.

### **Remco Neumann, PoR Environmental management (15-8-2018) and (4-7-2018)**

There have been several dilemma-discussions about investing in international projects where coal fired power plants are included in the plans. According to Remco the policy of the PoR doing business in other countries is well defined, but energy transition is still a complex issue. The discussions about the coal fired power plant resulted in a complete overview of the different views on this dilemma.

The question is: Isn't it better to stop being involved in Brasilia/Indonesia because of the fossil fuel industry?

NO, instead of walking away, it is better to be involved try to influence the project in a good way. There are two examples why: 1) Like Tony Chocology. The main goal is solving the bad conditions. 2) Like PoR. Goal is to influence the fast-growing economy (population and associated needs) in a good way. Like stated in 2) the PoR can add value by being involved in such projects. Participating in international port projects depends on two things. PoR must benefit from it, but PoR must also add value for the local parties.

The statement of Allard Castelein about the applicability local rules where we do business must be interpreted as follows: Dutch/international standards must be seen as an ideal situation but when local rules are less stringent we may follow these rules.

Ester de Graaf, she is making the new strategy where amongst others the UN-SDG are addressed with (+++), (++) or (+) so more UN-SDG are addressed in the new strategy. You need to involve all stakeholders to get a full idea of the consequences of our business. You need this to make the right decisions. When this is not yet properly done in a project (like in KT) retry to start the dialogue with stakeholders.

### **Robbert Wolf PoR (8-5-2018)**

In his opinion there are still enough degrees of freedom to play with during my research. For example, the location/lack of space. Look at possibilities to mitigate the impact or even create a positive impact. So, advice:

1. Impact study (river, resettlement, fisherman, mangroves). (us eKTIGP 11 March 2017)
2. BwN element, optimisation of project. This may be out-of-the box ideas but still useful for PoR.
3. Is this applicable to other port projects in Indonesia.

Erik Broos indicated that my BwN idea must be within the boundary conditions of the business case. Robbert says that I must not limit myself, so eventually I can find a solution which looks too expensive at first site but may be profitable in the long term.

### **Kees Kleinhout, PoR Port Planning (7-5-2018)**

The philosophy of managing a port is in Indonesia totally different compared to for example the port of Rotterdam, where the government finances the basic infrastructure and the companies buy their position inside the port (land lord port model). The Port of Rotterdam authority handles

with a commercial point of view. In Indonesia the companies pay their own infrastructural facilities (like jetties) and port management is done by a governmental body Pelindo.

The ambition is to create a container hub in the port of KT. At the moment, it is still unimageable that the port of KT will be a key player like Singapore. KT is still a very small port. So, development must be realised in steps. First by attracting industries in the port area (like cement and energy), then serving the hinterland as a transshipment port. At the end this will attract international companies to settle at KT. It is impossible to start as a transshipment hub port.

**Willem Dedden (director PoR Indonesia) (7-5-2018)**

Possible input for my research: look for (dis)advantages of hard structures (jetties/trestles) versus land reclamations. The latter has more impact on the environment than the structures on poles, but the hard structures are less efficient. In Indonesia there is no hard knowledge about coastal dynamics, so in port projects land reclamations are mostly avoided. It is difficult for them to map the impact of such a land reclamation (or breakwater).

# G Volume and rough cost calculations mangrove breakwater

In excel model, the elevation parameter (h) can be adapted. In Figure 62 the dimensions are indicated in the cross-section. In blue an extra area is added to compensate for the extra volume needed close to the deep trench. Marked in orange, it is clear that the majority of the needed volume is needed to construct part 3 and part 4.

Elevation horizontal part:

1,6 mCD

Dimensions [m]					
Part	Length	depth_left	depth_right	h_left to 1,6mCD	h_right to 1,6 mCD
1	1500	-0,5	-0,5	2,1	2,1
2	910	-0,7	-0,7	2,3	2,3
3	700	-3	-3,6	4,6	5,2
4	700	-5	-5,6	6,6	7,2
location 5		-5,5	-8	7,1	9,6

s1	s2	w1	w2	w3	w4
400	3	150	640	1,8	1,8
400	3	150	640	6,45	5,55
400	3	150	640	13,8	12
400	3	150	640	20,4	15,75

Areas [m <sup>2</sup> ]								
Part	Asquare	Aundersquare	Aslope-inner	Aslope-out	Ainner	Aouter	Aextra-trench	Atotal
1	240	90	512	512	385,08	385,08	0	2124,16
2	240	300	512	512	1194,268	1389,868	0	4148,135
3	240	645	512	512	2608	3007,48	4217,01	11741,49
4	240	903,75	512	512	3442,688	4490,72	4358,64	14459,798

Volumes [m <sup>3</sup> ]	(RHDHV, 2017a)	
	Vfill	Costs/m <sup>3</sup>
1	3,19E+06	10
2	3,77E+06	10
3	8,22E+06	10
4	1,01E+07	10
Total	25301944	

Costs [USD]	
Part	Costs
1	3,19E+07
2	3,77E+07
3	8,22E+07
4	1,01E+08
Total	253,019441 million USD