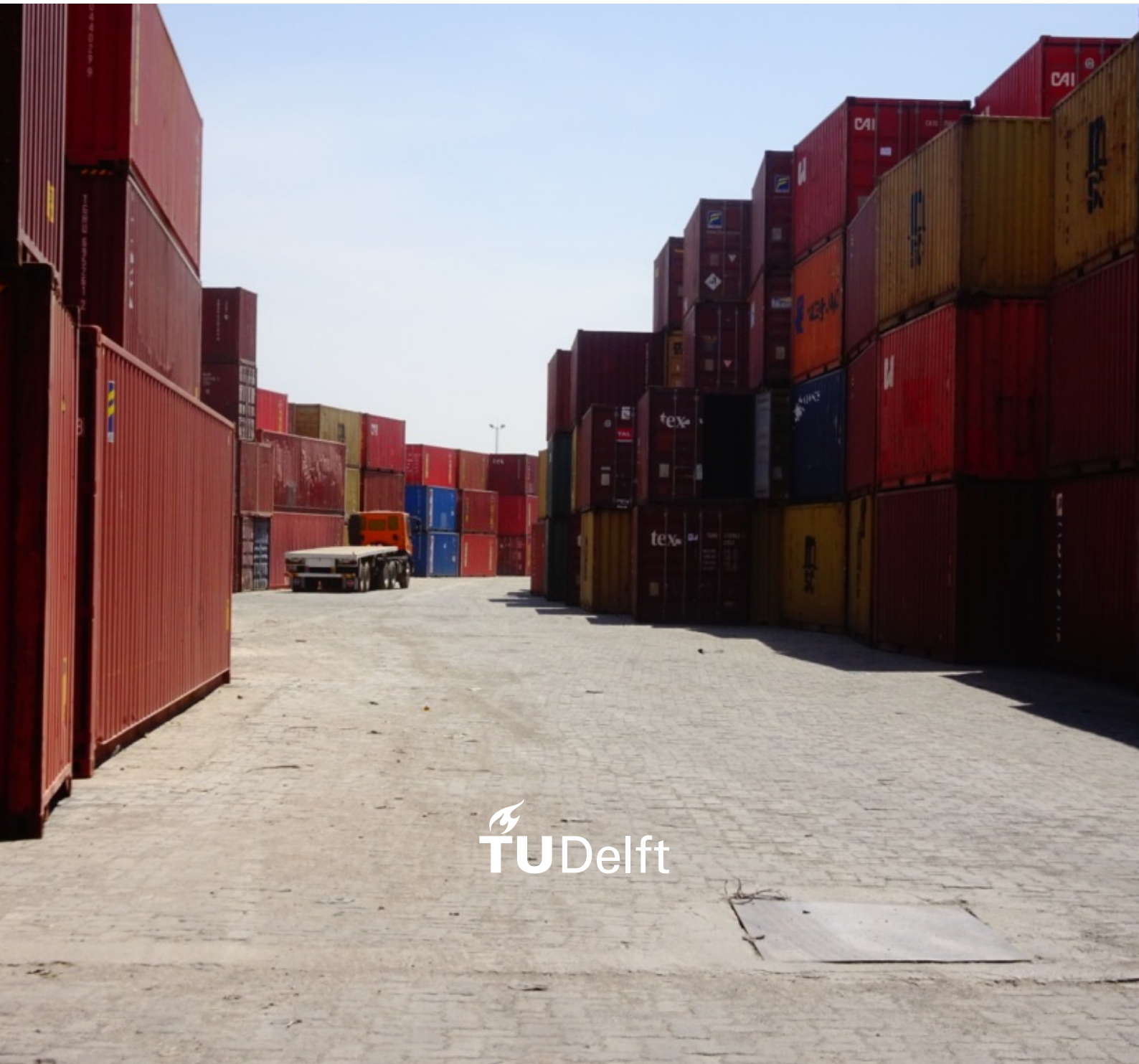
Anniek Sofie Munters

Evaluating sustainable dry port expansion in Africa

A stakeholder inclusive approach for evaluating layout alternatives of Modjo Dry Port, Ethiopia



Evaluating sustainable dry port expansion in Africa

A stakeholder inclusive approach for evaluating layout alternatives of Modjo Dry Port, Ethiopia

By

Anniek Sofie Munters

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Preface

Container terminals fascinate me endlessly. Their size, their complex logistics and their importance for the global economy make them attractive study objects. Because of the impact of a container terminal on the logistics chain as a whole, changing the operations affect a large number of stakeholders. The interplay between stakeholders, the power of specific groups and the politics behind container terminal development interest me. Sparked by a project considering container terminal development in Argentina, I was curious to deepen my knowledge about this topic in a new environment.

Almost a year ago I discussed with Prof. Lóránt Tavasszy the possibilities of conducting part of my master thesis in Africa. An expansion project considering a dry port in Ethiopia was the first possible thesis topic we discussed. He brought me in contact with Dr. Bikila Teklu from Addis Ababa institute of Technology and helped me to get in touch with Paul Brenton, senior economist at the World Bank in Ethiopia. All parties aligned, and thanks to a grant from the Holland Scholarship Fund, I could perform part of my research in Addis Ababa. I could not have been happier with the way things worked out. I want to express my gratitude to several people that supported me during this period.

First and foremost, I want to thank my graduation committee for guiding me through this challenging period. The meetings over Skype are not ones to forget easily. My absolute favourite was the midterm meeting where we managed to discuss the progress from five different locations. Thanks to Jafar Rezaei, for his immediate feedback and advise on working systematically. Bikila Teklu, for hosting me in Addis Ababa, providing the contacts I needed and for his valuable feedback on the interim documents. My gratitude also goes out to Lóránt Tavasszy, who in addition to bringing me into contact with the World Bank in Ethiopia, has been hugely inspirational throughout the research period. Thanks to Bart Wiegmans for his support, feedback, interest in the project and being the sparring partner throughout my thesis. His input has been very valuable for the final product.

Secondly, I would like to thank everyone at the World Bank in Ethiopia for helping and providing support for the study when I asked. I especially want to thank Paul Brenton for the opportunity of taking a look behind the curtains of how the World Bank operates in Ethiopia. It has been extremely informative, challenging and fun. Of course, I want to thank Mike for sharing injera every day at noon and for making me feel welcome in Ethiopia.

Lastly, I want to thank my brother, Jan, for proofreading my thesis and helping me when I asked. I have enjoyed our discussions and his intuitive grasp of linguistics majorly improved the readability of the final product. Without a doubt, I could not have done this without the support of my parents, brothers, and friends. Not only during my thesis, but throughout the 7 years of studying you have been a true support.

I hope that my research will proof helpful for the sustainable development of Modjo Dry Port.

Anniek Sofie Munters - Amsterdam, April 2019

Summary

Key words: Dry port expansion, sustainability, evaluation framework, Ethiopia, Modjo Dry Port

Introduction

Ports are the most important nodes in the supply chain of cargo and improving their sustainability will positively affect t the sector as a whole. This improvement can be achieved by incorporating stakeholders in the process of port development. Social, environmental and economic development achieved together are defined as sustainable development. Integrating social and environmental sustainability in the concept of economic development of the cargo transportation sector has been increasingly adapted. However, there is still much to gain in this prospect on a global level. Dry ports in the hinterland of seaports offer a sustainable solution to a number of challenges that occur on land.

In the prospect of sustainable port development, Ethiopia is an interesting country to study because of its rapid and relatively stable economic growth since 2005 and its low logistics performance. This study is built around a dry port expansion project in Ethiopia, for which a 150 million USD loan from the World Bank recently became available. Modjo Dry Port (MDP) is located close to the capital of Ethiopia and its largest production and consumption areas. The dry port will be rebranded as a *green hub,* in which it seems that the importance of environmental, and to a lesser extent, social factors are recognized. Decision makers stress the importance of diversification of cargo, resulting in the need for expansion of the port area. In addition, operational efficiency should improve to decrease the current dwell time of 50 to 60 days. Before acting directly, the sustainability of the alternatives according to different stakeholders, should be considered. Incorporating sustainable development in the project in general is a significant challenge. This leads to the formulation of a research question.

Research question: How to evaluate strategic alternatives for sustainable expansion of Modjo Dry Port?

This study describes a method on how to develop a number of distinct alternatives, and proposes a framework for the evaluation of sustainable dry port expansion. Such an evaluation tool for the dry port site specifically does not yet exist. The framework is tested for MDP in Ethiopia. The study also addresses a larger challenge on incorporating sustainability in developing countries. The tool should therefore be easily applicable and fluid in the sense that it can be adapted for comparable cases.

Alternatives for Modjo Dry Port

Dry ports are generally characterized by offering seaport functions, and being connected by rail to a seaport. However, their services and layouts vary widely. The available literature is largely limited to case studies which results in a lack of consolidation contributing to the wide spread in functions of dry ports. The operations of MDP are discussed according to the twelve dry port characteristics. Input is derived from four different types of sources: literature

considering characteristics of dry ports, literature on container port design, interviews with stakeholders and observations at the dry port. The characteristics that are grouped as size are cargo type, multimodal connection, dwell time and the size of the dry port. The characteristics grouped as operational efficiency are value added services, warehousing, equipment, automation and ground infrastructure. In addition, based on interviews and observations, the dry port characteristics demand, safety and employment arose. The most basic information on MDP is that it only handles import and empty containers, it is connected to rail since 2018 and its throughput grew since its opening in 2009 to 133.070 imported TEU in 2017. An overview of the layout of MDP is shown in Figure 0-1.

Figure 0-1. Layout of MDP

For the development of the alternatives of MDP, two overarching themes at the dry port were identified: operations are inefficient with dwell time of 50 to 60 days on average, and there is no diversification of cargo. Based on these themes three alternatives for MDP are defined (Figure 0-2) and the twelve dry port characteristics are estimated for each.

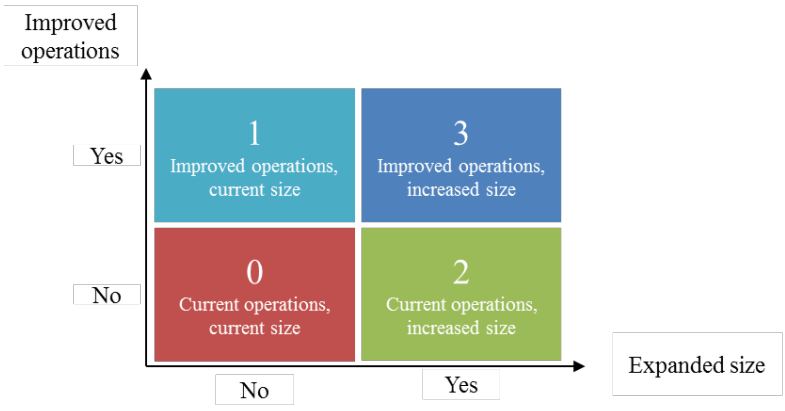

Figure 0-2. Strategic design alternatives for the expansion of MDP

A demand forecast for MDP helps in determining the suitability of each alternative. Based on Ethiopian GDP forecast and the expected market share of MDP, six scenarios for future throughput of the dry port are defined. Even in the minimum scenario a slight growth in container throughput is expected, indicating the need for expansion of MDP. The alternatives are to a more or lesser extent suitable to handle the different projections and phased expansion seems a plausible option.

Methodology

For the sustainable evaluation of Modjo Dry Port the Multi-Actor Multi-Criteria-Analysis (MAMCA) is used because it explicitly incorporates stakeholder incentives in a more traditional Multi-Decision Criteria Analysis (MCDA). The methodology consists of seven steps. In step one and two the problem, alternatives and stakeholders are identified. In the third and fourth step evaluation criteria and their indicators are defined. An evaluation matrix, including weights of different stakeholder groups is constructed in the fifth step. In the sixth and seventh step the alternatives are classified, and the aggregated best alternative is selected.

Results

In the first steps, four stakeholder groups for MDP are defined: internal, community, public policy makers and private companies. A total of 23 stakeholders participated in one, or more phases of the study.

In the third and fourth step, a framework for evaluation is constructed, based on literature and stakeholders' input. The criteria are categorised based on the three pillars of sustainability: social, environmental and economic sustainability. The main pillars are equally important to achieve sustainability. Each pillar should have a comparable and manageable number of subcriteria – aiming for three to five for each level. Based on 19 papers, a total of 38 evaluation criteria for dry port expansion are selected for the gross list. The gross list is subsequently validated by nine stakeholders of MDP of all stakeholder groups to indicate the most important criteria for MDP. Finally, the criteria are checked according to a set of quality conditions which they should meet: availability of data, minimal and not redundant. The final evaluation framework for sustainable expansion of MDP consists of 14 subcriteria (Table 0-1).

Subsequently, the weights for the criteria of the evaluation framework are determined by 16 stakeholders using a simple scoring method. The scores were normalised according to the max-min normalisation method and weights are determined by applying the linear normalisation sum-based method. Governmental and private companies are combined in the research because of the low response rate of market players, because their collaboration is already present and because the users' and operators' objectives considering sustainability are expected to be relatively similar. Their input is therefore expected to be relatively aligned. The weights have been determined for the stakeholder groups separately, and overall weights are calculated by averaging the values of the stakeholder groups. By taking the average all stakeholder groups are equally in the overall scores. The overall weights are shown in Table 0-1.

Table 0-1. Final evaluation framework for sustainable dry port expansion in Ethiopia including weights

Social	**0,33**	**Environmental**	**0,33**	**Economic**	**0,33**
Employment generation	0,23	Minimising emissions	0,31	Maximising VAS	0,23
Resettlement	0,21	Waste management	0,33	Transport cost & time	0,20
Safety: Employees	0,23	Protection of land	0,14	Productivity port area	0,18
Stakeholder consultation	0,25	Noise pollution	0,22	Multimodality	0,20
Dust	0,08			Reliability of service	0,19

It is notable that the criteria all receive a similar weight for the final score. This is true for the separate stakeholder groups as well, they tend to value the evaluation criteria as equally important. Because of this, there are no expected or unexpected large differences between the interests of the stakeholder groups considering the weights of the evaluation framework. Different reasons for the outcome of this analysis can be considered: educational purposes as stakeholders are unaware of the implications of the criteria, coincidence as the sample size is small, or complexity of weighing methodology as stakeholders found it difficult to weigh the criteria relative to each other. Alternatively, these could represent the true values and differentiation between the interest of stakeholder groups is small in an Ethiopian context.

In the last step of the MAMCA the proposed alternatives were scored against the current layout of MDP for all criteria in the evaluation framework. Few stakeholders participated, and their input is substantiated by the input of four experts in the field of dry port development. The weights are applied to the scoring, leading to the overall results shown in Figure 0-3.

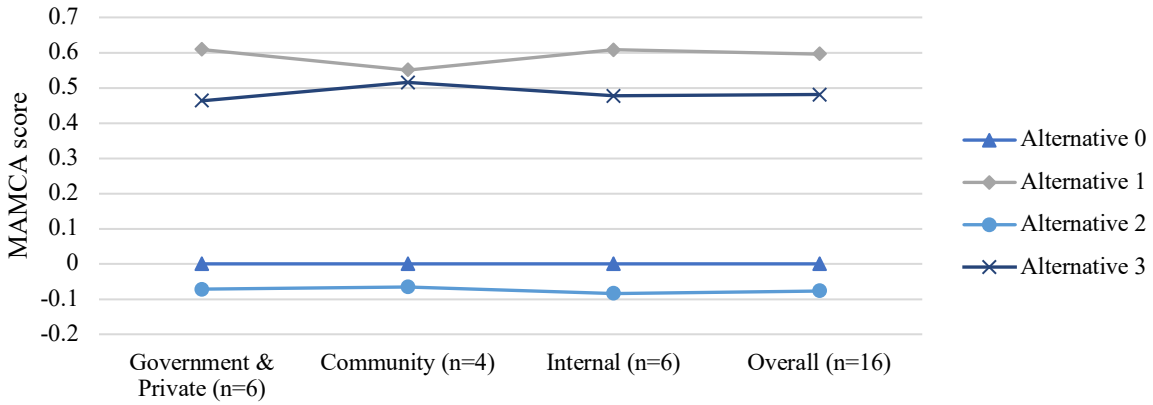

Figure 0-3. Overall MAMCA result for MDP expansion alternatives

The main take away of this analysis is that simply expanding in size is a less sustainable solution than improving the current operations and that this is similar for all stakeholder groups. The result is highly valuable for the DMU because it shows which criteria are important to consider for the expansion.

Discussion and Conclusion

A discussion is required to better interpret the results. Even though alternative 2 does not perform well considering sustainability, it is the expected direction for expansion of MDP. The sustainability of the alternative can be improved by focussing on dwell time decrease and automation of the basics of the container yard. *Resettlement of local community* and *protection of land* are criteria that should be handled with care. Because the evaluation framework does not consider the cost of the alternatives, it is possible that alternative 2 is indeed financially the most attractive. This observation increases the importance of the study, because sustainability indicators can be easily overlooked. Considering the demand scenarios there are many possible ways for the network in Ethiopia to develop. Especially dry ports closer to Addis Ababa are a suitable alternative for MDP. Stakeholder participation is an important part of the study, but it proved difficult to integrate a sufficient number of stakeholder responses in the analysis. When the value of the framework is acknowledged by the World Bank, they can play a more active role in evaluating project alternatives on sustainability. Their position is unique as they can

promote a sustainable stakeholder inclusive approach using the developed evaluation framework. The result could be improved by incorporating a large sample size, and doing the assessment backed with more data. The outcome of the evaluation can ultimately be used by the DMU to steer their choices. The cooperation of the DMU and other influential actors is therefore a major enabler for the value of the analysis.

The sustainability of alternatives for MDP can be evaluated by ranking the different alternatives according to a set of carefully selected criteria. These criteria are subdivided into social, environmental and economic criteria, all equally important to achieve sustainable development. Sustainability is improved by incorporating stakeholders in the analysis to ensure their involvement in the project, and to identify the main challenges. By systematically analysing the interest of the stakeholders using weights for the criteria, the most sustainable expansion direction is determined. By using the evaluation framework as provided, stakeholder preferences concern the sustainability of alternatives. For MDP specifically, stakeholder groups showed similar interests, and the preference for different alternatives is equal amongst the groups. Analysis shows that the alternatives improving operation efficiency score markedly higher on sustainability.

Recommendations for research are: quantifying the criteria from the evaluation framework for the different alternatives, researching future demand of MDP in more detail considering policy implementations of the government. Improving the evaluation framework by incorporating a larger set of stakeholders, applying a different method and expand the study to a different region or a different contact. Finally, the relation with the DMU should not be underestimated.

For management it is advised to use the developed tool for evaluating the sustainability of the alternatives of MDP expansion. Either by integrating stakeholders into process as was done in this study, or as a reference for ranking the alternatives based on sustainability themselves. Additionally, the community and internal stakeholder groups should also be considered for the expansion, where current focus is on the market players only. Moreover, future policy implications that affect the demand of MDP should be considered, and proactively acted upon to prevent unnecessary and unsustainable investments. Finally, EMAA and the WB should consider the outcome of this study and without disregarding the necessity for growth in size, the main focus in developing sustainable alternatives should be operation efficiency.

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Abbreviations

AHP	Analytic hierarchy process
BoL	Bill of Lading
BWM	best-worst method
(S)CBA	(Social) Cost benefit analysis
CY	Container Yard
DMU	Decision Making Unit
EMAA	Ethiopian Maritime Affairs Authority
ERC	Ethiopian Railway Cooperation
ESLE	Ethiopian Shipping and Logistics Service Enterprise
ETH	Ethiopia
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoE	Government of Ethiopia
HPC	Hamburg Port Consulting
IAPH	International Association of Ports and Harbors
ICD	Inland container depot
IMT	Intermodal transport
KPI	Key Performance Indicators
MAMCA	Multi actor multi-criteria analysis
MDCA	Multi-criteria decision analysis
MDP	Modjo Dry Port
MMT	Multimodal transport
NGO	Non-governmental organisations
PIANC	World Association for Waterborne Transport Infrastructure
RoRo	Roll on Roll off
SDG	Sustainable Development Goals
TEU	Twenty-foot equivalent unit
TOS	Terminal Operating System
TU Delft	Delft University of Technology
UN	United Nations
VAS	Value-added services
WB	World Bank Group


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1 Introduction

In Chapter 1 the purpose and contents of this report are discussed. First, the background of the topic is described, after which the research motivation is discussed. Then, the research is introduced, by stating the main questions and the scope. Lastly, the content and the structure of the report are shown.

1.1 Background: sustainability in the cargo transport sector

In the last decades, growth of international trade has been larger than ever. It is expected that this trend will continue, and that global trade will grow by a factor of 3.5 from 2017 to 2050 (International Transport Forum, 2016). Vessel sizes are growing in response and so are the most important nodes in international trade: ports.

Expansion and development of ports affect our society on three main levels: socially, environmentally and economically. In general, port development is positively associated to economic growth and negatively to the impact on the environment. International trade contributed 56% to global GDP in 2016, which increased to 71% in 2017 (World Bank, 2018b). But the sector's contribution to worldwide CO_2-emissions was also significant: around 7% of the global total (Gurtu, Searcy, & Jaber, 2017). The impacts on the last pillar, the social effects of port development, are more disputed being both positive, e.g. job creation, and simultaneously negative, e.g. safety (Schipper, Vreugdenhil, & de Jong, 2017). Until recently, social and environmental aspects of port development have been neglected in both literature and practice. Fortunately, integrating (partly) social and (mainly) environmental sustainability in the concept of economic development of the cargo transportation sector has been increasingly adapted in developed economies. However, there is still much to gain in this respect on a global level.

Sustainable port design and port development

A commonly accepted definition of sustainable development is "*the development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987). Studies on port development increasingly use the three pillars of sustainability as a primary framework, which is referred to as sustainable port development (e.g. Denktas-Sakar & Karatas-Cetin, 2012; PIANC, 2014b; Schipper, Vreugdenhil, & de Jong, 2017; Slinger, Taneja, Vellinga, & Van Dorsser, 2017). This has been defined as a long term dynamic effort, based on continuous learning and improvement, requiring the simultaneous pursuit of social responsibility, environmental quality and economic prosperity (Vellinga, Slinger, Taneja, & Vreugdenhil, 2017). Figure 1-1 shows the relation between these three aspects.

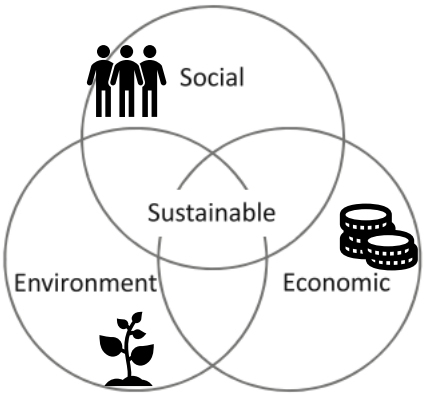

Figure 1-1. The three pillars for sustainable development (Purvis, Mao, & Robinson, 2018)

To achieve sustainable growth, including a variety of stakeholders throughout the process of port development is necessary. Stakeholders' input is included in all stages of the standard, iterative design model as in Figure 1-2 to increase the sustainability of port development. The cyclic process starts with the identification of the requirements. Then, the initial design is developed which is subsequently tested and evaluated. Based on the evaluation, the design is improved, and the cycle is repeated.

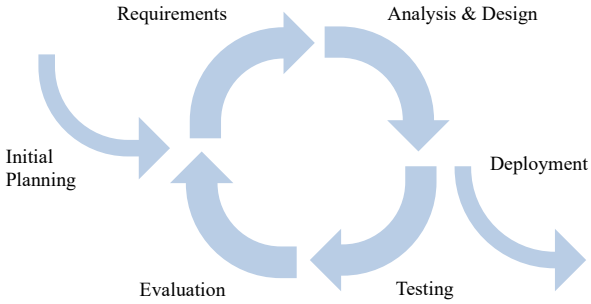

Figure 1-2. Iterative-Design model (Gossain & Anderson, 1990)

1.2 Research motivation

Considering sustainable port development in developing economies, Ethiopia is an interesting country to study because of its stable economic growth and challenging logistics environment.

Cargo transportation in Ethiopia

Ethiopia currently undergoes a rapid and relatively stable economic growth. It is one of the fastest growing economies in Africa with rates of over 8% per year. Since 2014 Ethiopia has been, and is projected to be until at least 2023, among the top 6 fastest growing economies worldwide (IMF, 2018). The country is situated in the Horn of Africa (Figure 1-3) and is landlocked. With a population of over 100 million people it is the second most populous country of the continent. A major challenge for achieving the projected economic growth is the underdevelopment of the logistics sector. On the Logistics Performance Index by the World Bank, Ethiopia scored 126th (out of 160 participating countries) in 2016 (World Bank, 2017b). In comparison: Botswana and Uganda, other African countries similarly landlocked, ranked

57th and 58th respectively. In addition, trade makes up only 31% of Ethiopia's GDP (World Bank, 2018b) which is low compared to the global average (56%).

Figure 1-3. Ethiopia is located in East Africa, neighbouring Somalia, Kenya, South Sudan, Sudan and Eritrea. The main seaport (Djibouti) and Ethiopia's largest dry port (MDP) are indicated. Adapted from Google Maps (2018)

Ethiopia is dependent on the seaports of neighbouring countries for their international trade since 1993, when Eritrea and Ethiopia split in two countries and the latter became landlocked. Goods are currently imported and exported via Djibouti, the Port of Sudan, Berbera in Somaliland, Mombasa in Kenya, and recently trade via ports in Eritrea opened as well. To improve inland trade logistics, the Government of Ethiopia (GoE) is developing a network of dry ports throughout the country.

Role of government in operation of dry ports

The GoE owns and operates all major institutions associated to trade. For example, the railway, the dry ports, and most transport vehicles in Ethiopia are owned by the government. In 2011, the GoE introduced the multi- and unimodal system for container trade, which is typical for Ethiopia (Appendix A). Multimodal transport is handled by governmental institutions only. The system has two main implications. Firstly, importers are required to use a governmental institution for their entire supply chain. Secondly, this governmental institution uses the dry ports in Ethiopia for clearance of cargo. Approximately 75% of the total container import of Ethiopia is transported via the multimodal system. As other (private) companies cannot interfere in this process, the government has a monopoly over the supply chain of international trade, which contributed to the inefficient and expensive operations as they currently are. The two most important governmental institutions in international trade are:

- Ethiopian Shipping & Logistics Service Enterprise (ESLSE): they are responsible for the operation of the dry ports in Ethiopia, the freight forwarding sector, the shipping sector and they are involved in the corporate service sector (ESLSE, 2015)
- The Ethiopian Maritime Affairs Authority (EMAA): they are the body that ensures the standards of Ethiopia's maritime training and seafarer certification, marine & dry ports, and transport logistics infrastructure (EMAA, 2018)

Transportation costs in Ethiopia are high due to, amongst others, the lack of competition and the dominant role of the government in the sector. This poses significant challenges for

importers and exporters to viably run their business. Especially export lags behind as prices for products are not competitive on the international market. This leads to a major trade imbalance: the total value of import is currently five times that of the total value of export The diversification of export has been identified by the GoE as an important goal to sustain growth and they are investing heavily in infrastructure related projects to accomplish this goal (Federal Democratic Republic of Ethiopia, 2015).

Study system: expansion of Modjo Dry Port

The largest dry port in Ethiopia, Modjo Dry Port (MDP), opened in 2009. It is located roughly 80km south of Addis Ababa, the capital, and close to the largest consumers, producers, importers and exporters (World Bank, 2017a). MDP handled approximately 230.000 TEU in 2017, which corresponds to almost 40% of Ethiopia's total container throughput. The dry port is an important hub for employment as over 1,000 people are employed at the dry port. It lies on the "Ethio-Djibouti corridor", connecting the seaport of Djibouti to Addis Ababa by road and rail. Currently 95% of Ethiopia's containerized cargo is handled at Djibouti (approx. 600.000 TEU). The journey by road between those locations is almost 700km and takes three days, because of the poor conditions of both roads and trucks (Figure 1-3). Even so, 86% of the total transport time is currently spent at MDP (World Bank, 2017a). Dwell times at MDP are between 50 and 60 days on average, causing permanent congestion in the dry port area. Operations at the dry port are the largest bottleneck of the corridor and improving those will affect the total efficiency of the supply chain. Expansion of the dry port is required to handle future demand.

The World Bank (WB) approved a loan of 150 million USD for the Ethiopian Trade Logistics Project (ETLP) in 2017 to finance the expansion of MDP. The aim of the ETLP is to improve in operational capacity, efficiency, and a range of logistics services at the dry port, by, among others: a bulk storage and bagging facility, and improved container yard and equipment. As part of the ETLP, the dry port will be rebranded as *Modjo green logistics hub* and seems to recognize the importance of sustainable development.

1.3 Research introduction

The goal of the research is to determine the most sustainable expansion direction for MDP in Ethiopia. Possible alternatives for the expansion of MDP have not yet been determined by EMAA, ESLSE or the WB. The focus lies on evaluation of the alternatives by carefully integrating the interests of stakeholders in the process, to achieve the three layers of sustainable dry port development: social, environmental and economic. Integrating stakeholders in development of dry ports in East Africa has not yet been done in literature and is therefore of great value. Using an academic approach, this study proposes a framework to evaluate dry port expansion and development in Ethiopia, and possibly in a wider African context. The newly constructed evaluation framework can be used to evaluate the sustainability of the alternatives for MDP in a later stage. The framework can also be used by the WB as mandatory to evaluate the sustainability of alternatives and systematically give stakeholders a voice.

1.3.1 Research questions

From the problem definition above, the following research question is defined

How to evaluate strategic alternatives for sustainable expansion of Modjo Dry Port?

To answer the research question, the following sub-questions are subsequently addressed

1) What is a suitable framework to evaluate dry port expansion by different stakeholders in East-Africa?
2) What are suitable design alternatives of Modjo Dry Port based on the current situation?
   - What scenarios for cargo flows in Ethiopia, and specifically the flows through Modjo Dry Port, can be expected?
3) How can the interest of different stakeholder be aggregated to develop the most suitable alternative?
4) How do the strategic alternatives perform for different stakeholder groups?

1.3.2 Scope

In the following section the most important restrictions for the research are presented.

Exploratory demand study. The market study required to determine future demand of the terminal is limited due to data and time constraints. The market study of two consultancy firms will be used to complement and confirm the forecast of the current study.

Cargo segments. Throughout the research different cargo segments are considered for dry port design, e.g. bulk, cold storage, containers. However, no distinction within cargo segments is made.

Terminal design criteria. A framework for strategic terminal design will be developed. It is not guaranteed that all aspects of dry port design are included in the framework. However, the most general and important characteristics of terminal design will be included.

Stakeholders. A number of relevant stakeholders will be identified that agree to participate in the research, it cannot be guaranteed that all important stakeholders are included. If major stakeholders, such as the dry port operator or the public entity choose not to participate in the research, the analysis will still be executed as proposed with stakeholders that do participate. The final document has a different value and serves as a document to support the decision-making unit and give other stakeholders a systematic voice.

Dry Port Location. As MDP is already in operation, other suitable locations for a container hub are not considered.

Operation model. Most commonly ports are operated by the landlord model. However, MDP is operated by the government solely. It is not in the scope of this research to examine the possible operation strategies that the port authority can employ.

Complementary to WB research. Considering timespan there are three types of port planning: short, medium and long-term planning. The WB is currently focussing on short and

medium-term planning, in this study long term developments are considered. Ultimately, the research can be used by the WB to make short-term decisions. Section 5.5 deals with this issue.

Cost. Operational and investment cost of the different alternatives are not included in the research because of the exploratory phase of the project and the associated limitation in data availability.

1.3.3 Structure

For this research, four phases can be distinguished: a literature study focussing on dry port characteristics and evaluation criteria (Chapter 2), elaboration of the used methodology to develop alternatives, and for sustainable evaluation of the dry port (Chapter 3), study system of the MDP and possible alternatives (Chapter 4) and the analysis of expansion alternatives of Modjo Dry Port (Chapter 5). In Chapter 6 conclusions are drawn and recommendations for future research are proposed. The research approach is shown in Figure 1-4. In this thesis the first iteration for the design of the expansion of MDP is performed (Figure 1-2), from data collection to evaluation.

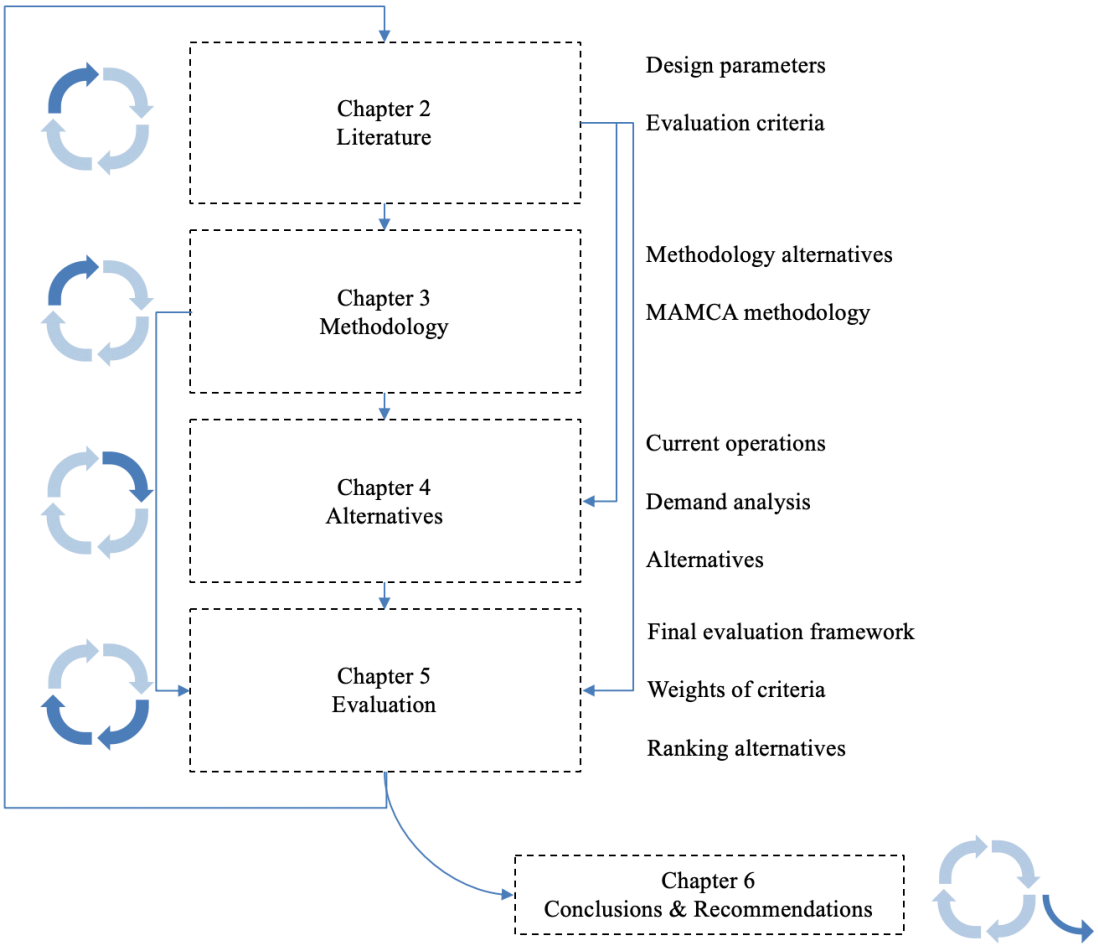

Figure 1-4. Flow diagram of research


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2 Sustainable dry port development and evaluation: Literature review

Chapter 2 covers the literature study, which is part of the primary step in the dry port design process. Relevant studies considering dry ports and their sustainable development are discussed to understand their purpose and to determine a list of dry port characteristics. Additionally, evaluation criteria for dry port expansion are elaborated on with reference to social, environmental and economic sustainability.

2.1 Dry ports: definitions, classifications and characteristics

In this section the concept of dry ports, the terminology and classification are described. The aim of this section is for the reader to understand how MDP compares to other dry ports and to define a set of nine dry port characteristics which follow from the literature. The characteristics are subdivided into two main groups: based on efficiency and based on size. In addition, two gaps in literature considering this topic are identified: the lack of an evaluation framework for sustainable dry port development, and missing studies considering dry ports in East Africa.

2.1.1 General concept of dry ports

Definition

The following definition for dry ports by (Roso, Woxenius, & Lumsden, 2009) is widely cited in literature: *"a dry port is an inland intermodal terminal directly connected to a seaport by rail, where customers can leave and/or collect their standardised units as if directly to the seaport"*. Accordingly, a dry port has two main characteristics. It has a multimodal rail connection to at least one seaport, and it offers seaport functions. A more general working definition is provided by (UNESCAP, 2013): *"a dry port can provide services for the handling and temporary storage of containers, general and/or bulk cargoes that enters or leaves by any mode of transport"*. Both definitions are comparable to the extent that containers are handled inland, where the latter exclude explicit mention of a rail connection. The former definition by (Roso et al., 2009) is most commonly kept in literature. Dry port research can be considered as a relatively new concept in the literature of trade transportation, compared to traditional port research, about which there have been significant number of publications in the last decades and even centuries before. Until 2000, the number of articles considering the dry port concept was limited to just three (on www.scopus.com) and it increased since. (Witte, Wiegmans, & Ng, 2019) reviewed publications considering the dry port concept and highlighted the increase in attention for the topic recently. They additionally indicated that a wide diversity of definitions, actors, functions, and levels are used throughout these studies. This variety exists both due to the unique nature of a dry port, increasing the difficulty to develop general

definitions, and due to mostly individual case studies which failed to lead to conceptualization of the term.

Comparable terminologies

This resulted in the rise of a vast number of terms that are used interchangeably with "*dry port*". Examples are: inland container depot (ICD), inland port, inland terminal, logistics centres, freight village and extended gate (Monios & Wilmsmeier, 2012; Nguyen & Notteboom, 2019; Roso, 2013; Witte et al., 2019). The use of these terms varies based on geographical location, period of research and functions of the site. In the current study, the term *dry port* is used to refer to MDP and the definition by (Roso et al., 2009) for dry ports is maintained. The reasons for using *dry port* are threefold:

- *Dry port* is most often used in literature in comparison to the other terminologies mentioned (Nguyen & Notteboom, 2019; Witte et al., 2019). Especially in Africa it is common to refer to *dry ports* considering similar sites.
- The site offers 1) seaport functions and 2) is connected to a seaport by rail (Roso et al., 2009).
- The site is currently referred to as Modjo Dry Port and for consistency that terminology is applied in this study.

The last reason needs an asterisk as the site is possibly being rebranded as *Modjo green logistics hub*. However, this rebranding is unsure, and the first two reasons are sufficient to refer to MDP as a dry port.

Sustainable (dis)advantages in the transport network

The use of dry ports in the hinterland network has a perceived positive impact on the sustainability of the supply chain because of the possibility to use high capacity transport (Roso et al., 2009; StratMoS, 2009). In Table 2-1 examples of advantages of dry ports are listed for all of the three pillars of sustainability. A comprehensive overview of potential benefits and of dry ports in the hinterland network can be consulted in Appendix F.

Table 2-1. Advantages of dry ports in the supply chain (Roso et al., 2009; Wu & Haasis, 2018)

Pillar	Example of advantage dry ports in hinterland network
Social	Job creation inland
Environmental	Reducing freight emissions by consolidation transport
Economic	Transport cost reduction / Port capacity increase

These benefits are (partly) visualized in Figure 2-1. For example: the dry port in the bottom figure ensures employment opportunities inland (social); multimodal transport and consolidation of freight reduce emissions (environmental); increased productivity at the seaport due to a lower dwell time (economic).

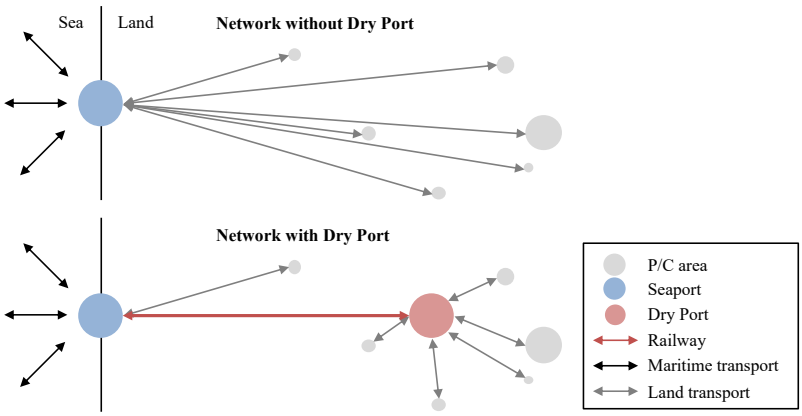

Figure 2-1. A seaport without and with a dry port in its network (Roso et al., 2009)

Sustainability of the dry port itself

Because of the broad and clear upsides, the development of a dry port is an interesting opportunity when improving the sustainability of a seaport. Negative effects of this measure on the transport system, and on the surroundings of the dry port have been less extensively discussed. The net effect on sustainability is disputed, as dry ports move the seaport problems inland, instead of solving them (Rodrigue & Notteboom, 2009; Witte et al., 2019). For example, increases in congestion, emissions and nuisance are going hand in hand with the development of a dry port (Black, Roso, Marušić, & Brnjac, 2018; Witte et al., 2019). In addition, the presence of the dry port in the network enables an increase in capacity of the seaport. As a result, emissions per ton cargo might decrease, but total emissions grow due to the increase of throughput. A critical view on the sustainable effect of dry port development on the dry port location itself is lacking. Because of increasing interest for dry port development and sustainability, this is an important topic to address.

> **Literature gap.** Studies on the sustainable benefits of dry ports in the transport network are extensively available, whereas those on sustainable development[1] of the site itself are rare. This study aims to fill this gap in literature by evaluating a dry port expansion project as its own system and constructing an evaluation framework for the sustainable expansion of dry ports specifically.

2.1.2 Dry port characteristics

Dry port characteristics can be used for the interpretation of expansion alternatives. In literature, dry ports are mostly classified based on functions, distance to the seaport and primary development aim (Nguyen & Notteboom, 2016). The former classification is related to efficiency and operational characteristics of a dry port, while the latter two are linked to the size and capacity of a dry port. These classifications are explained in more detail and dry port characteristics important for expansion are highlighted. An overview of the characteristics is shown in Table 2-2.

[1] Development of ports includes both construction of a new site as well as expansion of an existing port.

Efficiency and operational characteristics

The first classification of dry ports is based on the functions they offer. (Villiers, Mackay, & Serafino, 2013) identify three types of dry ports in addition to a dry port only having the core infrastructure. The services of different levels are shown in Figure 2-2. (UNESCAP, 2006) use a comparable classification where the simplest level, "core infrastructure", is referred to as a container yard, and the level of basic logistics services is referred to as ICD.

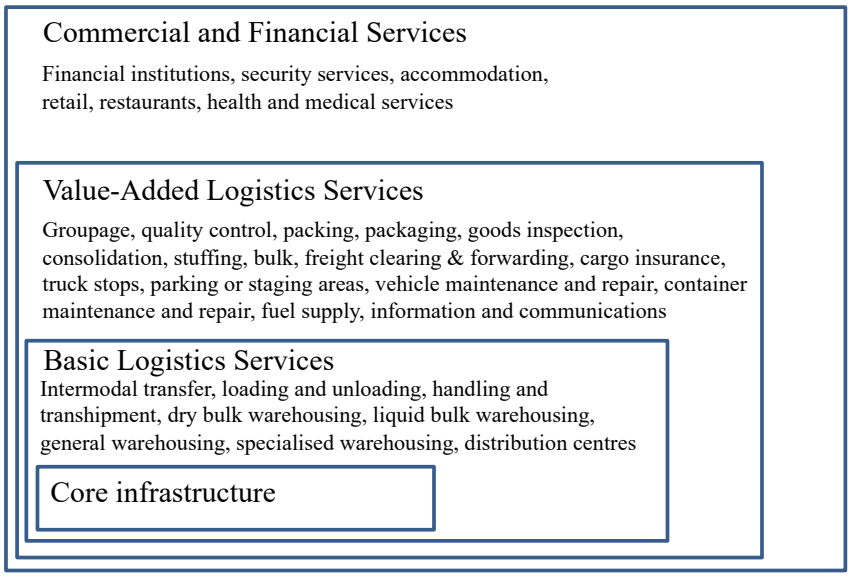

Figure 2-2. Dry ports can have different functions (Villiers et al., 2013)

The dry port characteristics based on this classification are offering warehousing and VAS. Offering warehousing encompasses most of the basic logistics services whereas offering VAS encompasses the next level (Figure 2-2). In addition to characteristics specific for dry ports, there are a number of parameters that affect efficiency of seaports as well as dry ports. Automation (or ICT), equipment and the quality of the ground infrastructure are those considered in this study (Mohseni, 2011; Zheng, 2015).

Size characteristics

The second classification is based on the distance between the dry and seaport (Rodrigue & Notteboom, 2009; Roso et al., 2009). Whether it is referred to as distant, midrange and close, or inland, satellite and gateway terminal, the implications for the functions are comparable. The benefits from distant, or inland dry ports are primarily due to the modal shift from road to rail (Roso et al., 2009). The midrange or satellite dry port is established predominantly for the consolidation of cargo, whereas the close, or inland dry port is primarily constructed to increase the capacity of the seaport. Even though this is true for dry ports in general, the distance between the two ports does not necessarily reflect on the characteristics and functions of a dry port.

The third classification is based on the primary developing aim of the dry port: import or export driven (Monios & Wilmsmeier, 2012). The import driven dry port is also referred to as outside-in dry port, as goods flow from outside the country to the hinterland, or a following port, as the seaport is largely involved in determining the throughput of the dry port. The counterpart, an export driven dry port is referred to as inside-out dry port, where the goods flow from inside

the country to the seaport. If the dry port plays a larger role in the supply chain, an alternative name is a leader dry port. It is generally believed that developed countries are likely to have more sea-driven dry ports than developing countries. Exporting shippers in developing countries are mostly small or medium-sized, and it is preferred to consolidate goods before transporting to the seaport (Nguyen & Notteboom, 2016). However, research on dry port development in Africa is insufficient and generalisations about countries in this continent are difficult to make.

The dry port characteristics based on these classifications are the multimodal connection, and cargo type that is handled such as import, or export containers. In addition to characteristics specific for dry ports, there are a number of parameters that affect efficiency of seaports as well as dry ports. In this study dwell time and the surface of the dry port are considered.

> **Gap in literature**. There is an imbalance in studies focussing on developing versus developed economies. Studies on dry port development in Africa are increasing, but still in the minority. From the 74 papers on Scopes that were found using the search terms: *"dry port" AND development* (between 2008 and 2018) that specified their location, only one was in Africa. When searching only for *"dry port",* five of the 148 studies were conducted in Africa. A number of studies considering dry ports in Africa have been conducted and their relevance is discussed here in brief. Researchers from China compared East-African dry ports with those in China, concluding that dry ports should develop proactively in Africa, creating their own opportunities (Gerald & Jin, 2016), basically, stimulating the inside-out or leader position of dry ports in the hinterland. (Kwateng, Donkoh, & Muntaka, 2017) assessed the feasibility and economic effects of implementing a dry port in Ghana's hinterland, as a solution to reduce congestion at the main seaports, as well as to reduce transportation cost. Considering sustainable development of dry ports in East-Africa has not yet been done in literature.

Overview design characteristics dry ports

Based on the classifications discussed in this section, a list of nine dry port characteristics is constructed that can support dry port expansion. In Table 2-2 the selected dry port characteristics for development are shown.

Table 2-2. Dry port characteristics based on (dry) port studies

	Dry port characteristic	What does it entail?	Sea / dry port lit	Reference
Size	Cargo type	e.g. containers, bulk, RoRo (import / export)	Dry	(Roso et al., 2009)
	Multimodal connection	Possibilities for multiple modalities	Dry	(Villiers et al., 2013; Zheng, 2015)
	Dwell time / capacity	Average dwell time	Sea	(Lee & Kim, 2013)
	Size	Size of the terminal	Sea	(Lee & Kim, 2013; Wiese, 2012)
Operations	VAS	e.g. packing, labelling, cleaning	Dry	(Roso et al., 2009; Villiers et al., 2013)
	Warehousing	General / specialized warehousing	Dry	(Villiers et al., 2013)

	Dry port characteristic	What does it entail?	Sea / dry port lit	Reference
	Automation / ICT	e.g. yard automation, special equipment	Sea	(Mohseni, 2011)
	Equipment	e.g. reach stackers, gantry cranes	Sea	(Mohseni, 2011)
	Ground infrastructure	"minimum water depth, margin to manoeuvre"	Sea	(Zheng, 2015)

2.2 Evaluation criteria for the sustainable development of dry ports

The second step of the research focuses on sustainable evaluation of the alternatives. The aim of this thesis is to evaluate different alternatives for dry port expansion in Ethiopia. To do so, it is common to assess the alternatives according to a number of specifically selected criteria or Key Performance Indicators (KPIs). In this section, studies on port evaluation projects and the associated evaluation criteria are reviewed.

2.2.1 Main criteria for the evaluation of dry port expansion

Criteria for evaluation have been classified in various ways, using various methods, depending on the aim of the specific project: main criteria can be defined before (Antão et al., 2016), or after (Gohomene et al., 2016) the identification of the subcriteria. (Schipper et al., 2017) assessed sustainability performance of ports according to the sustainability principle (Figure 1-1). The latter classification closely matches the aim of this study: evaluation of alternatives for dry port expansion based on their sustainability according to social, environmental and economic sustainability. These pillars are considered as the overarching themes under which all criteria are grouped. Evaluating dry port expansion on the three pillars of sustainability is all-encompassing for this aim, however, financial factors are not taken into consideration and should be assessed additionally.

Currently, economic benefits receive the most attention in literature (Rodrigue & Notteboom, 2009). In the last three decades the harmful effects of the cargo transport sector became increasingly apparent in research and practice (Schipper et al., 2017). For example, researchers found that biodiversity in the sea of, and around, port areas had decreased significantly (Gurtu, Searcy, & Jaber, 2017; Lam & Notteboom, 2014). In response, environmental sustainability of port development projects became more important, also by pressure from the communities and governments (Denktas-Sakar & Karatas-Cetin, 2012; Di Vaio, Varriale, & Alvino, 2018; Schipper et al., 2017). Social sustainability has been more difficult to implement, but its importance has been increasingly recognized (Denktas-Sakar & Karatas-Cetin, 2012).

Selection of criteria

The incorporation of sustainable growth in dry port research has been limited in comparison to seaport related studies (Lu, Shang, & Lin, 2016; Schipper et al., 2017). For the analysis of sustainability indicators of dry ports, research that considers seaport performance is also used as source of input.

For the selection of relevant literature for dry port performance/evaluation criteria, a combination of the following search terms at the TU Delft library, Scopus and Google Scholar have been used: *"sustainability", "port development", "port", "expansion", "dry port", "KPI", "Key Performance Indicator", "performance", "criteria"*. Additionally, papers have been added using the snowballing technique.

Based on these papers, a list of criteria is constructed. Two boundaries were set to exclude criteria that are not relevant for the research at MDP:

- Criteria related to the location of ports e.g. distance to seaport. The location of MDP is fixed and the research is focused on evaluating alternatives for this specific dry port. The alternatives will therefore perform equally for these criteria.
- Criteria specifically related to the maritime part of ports e.g. effect of growing throughput on seaports, maritime freights rates, impact on fishery and effects of dredging.

From a total of 19 papers and reports the gross list of criteria is determined. The literature included 14 papers published between 2012 and 2018 which all included a literature study for determining suitable KPIs, evaluation criteria or sustainability criteria for ports. Five of those studies were conducted in developing countries and twelve made mention of sustainability, or green/environment in their main aim. Except for one paper on location evaluation of a dry port, all research was focused on seaports. A master thesis with a comparable research question in Myanmar was consulted (Oosterwegel, 2018) and two MDP specific studies were considered when determining the gross list (EMAA, 2015, 2016). Lastly, the report by (Amber Coast Logistics, 2013), which made mention of approximately 100 indicators, was consulted to verify whether criteria were missed in the literature study. In Appendix I the overview of papers consulted is shown. As there was a large amount of overlap in the criteria, it is assumed that the most important criteria are included in the gross list.

As an additional dimension to the literature on sustainable evaluation criteria for ports, the Sustainable Development Goals (SDG) by the United Nations (UN) are linked to the criteria. These goals are widely accepted and give insight in links between the criteria and sustainability. In the SDG agenda, sustainable transportation is considered 'a key enabler for inclusive economic and social growth' (UN, 2018). In Appendix B the SDGs are explained in more detail.

In the following sections, the subcriteria for the three main criteria are elaborated on.

2.2.2 Social sustainability for dry port expansion

Social sustainability can entail a wide variety of measures, for example: social equity, liveability, health equity and community development (Keseru, Bulckaen, Macharis, & De Kruijf, 2016). In the last decades scholars, as well as port authorities, are making an effort to take social prosperity into account when developing the port area. The social effects of sea and dry port development are fairly comparable, which makes existing literature a useable source for the current study.

For example, (Schipper et al., 2017) define five social indicators for port development: climate change protection, employment, well-being, urbanization and safety against flood. The first

four KPIs are applicable for dry port development whereas the last is relevant only to seaports. The development of a dry port can have both a negative and a positive impact on these measures. A difference between sea and dry ports is the flexibility in the location of a dry port, compared to the more restricted location choice for a seaport. A dry port is restricted to the presence of a road, or rail line only, which can be constructed when necessary. The local community of seaports are (commonly) historically associated to the port, in the form of fishery or tourism, this is less so for dry ports. The community is usually employed at the port area, but to a lesser extent involved in the additional industries. The probability that the local community does not benefit from growth of a dry port is therefore greater (Del Saz-Salazar & García-Menéndez, 2015; Vellinga et al., 2017).

The social criteria found in literature are listed in Table 2-3 and consist of 14 different criteria. The criteria relate to six different sustainable development goals (SDG) compiled by the United Nations (UN).

Table 2-3. Social criteria from literature for the evaluation of (dry) port development

#	Criteria	# of citations	SDG
1	Employment generation	9	8
2	Replacement of local community	5	
3	Education for local community	5	4
4	Safety: Traffic	5	
5	Heritage and cultural impact	4	
6	Visual intrusion	4	
7	Quality of living	3	
8	Safety: employees	3	8
9	working environment	2	
10	Safety: diseases	2	3
11	Economic equality	2	10
12	Institutional, legal and political impact	1	16
13	Stakeholder consultation	1	
14	Gender equality	1	5

2.2.3 Environmental sustainability for dry port expansion

Compared to a seaport the system of dry ports is simplified significantly as the maritime part, with the accompanying environmental challenges, is not present. (Roso et al., 2009) addressed the “green” value of dry ports in the supply chain explicitly. In general, using rail transportation is less polluting than truck transport (Kim & Van Wee, 2009). This is dependent on, amongst others, the type of trucks and train that are used in the country of interest and the distance to be covered. Figure 2-1 shows a schematic depiction of the possible cargo consolidation due to the presence of dry ports in a seaport’s hinterland network. Examples of the negative externalities associated to dry port development are distribution of hazardous goods, dust generation, noise and light pollution. In addition, emissions will also increase in the port area.

In developed economies green ports, which take environmental sustainability into account, are becoming the standard. Negative externalities are then compensated for as part of the project. This principle is embraced, especially considering port development in Europe and such projects are classified as "green ports". Even though sustainable port development is becoming the standard in developed economies. In Africa this is not yet the case. The need to incorporate environmental issues is recognized, however, the implementation of the concept is still facing significant difficulties (IAPH, 2018). As there is a large potential for trade increase in Africa, it is necessary to understand the mechanisms driving port development and encouraging the adoption of green ports.

The environmental criteria found in literature are listed in Table 2-4 and consist of eight different criteria. They are considered under four different SDGs.

Table 2-4. Environmental criteria from literature for the evaluation of (dry) port development

	Criteria	# of citations	SDG
1	Minimizing GHG	14	15
2	Minimizing energy (type of source)	7	7
3	Waste management (recycling and hazardous goods handling)	6	12
4	Protection of land and natural environment	6	15
5	Noise pollution	4	
6	Light pollution due to 24h operations	2	
7	Existence of environmental programme	2	13
8	Soil pollution due to activities of the dry port, and industries around	1	15

2.2.4 Economic sustainability for dry port expansion

Dry ports enable the hinterland of ports to expand by improving cost-efficiency and the capacity of the transportation system. These advantages are the main driver of dry ports in most hinterland networks in developed economies, where all major hubs to a greater or lesser extend use dry ports in their hinterland network (Veenstra, Zuidwijk, & Asperen, 2012). Dry ports are less frequently found in Africa where trade volumes are generally lower and high capacity corridors are limited, or in bad shape.

The economic criteria found in literature are listed in Table 2-5 and compound 16 different criteria, and they relate to two different SDGs.

Table 2-5. Economic criteria from literature for the evaluation of (dry) port development

#	Criteria	# of citations	SDG
1	Maximizing value added services	7	8, 9
2	Transport cost & time	7	8
3	Income and profit port	5	8
4	Productivity port area	5	8
5	Throughput port	5	8
6	Investment cost and generation	5	8, 9

#	Criteria	# of citations	SDG
7	Cargo safety in port	5	8
8	Accessibility of multimodality	4	
9	Customs clearing efficiency	4	8, 9
10	Employment [also economic]	3	
11	Range of value-added services	2	8, 9
12	GDP generation (local and country)	2	8
13	Congestion	2	
14	Reliability of service	2	8
15	Automation	2	
16	Market share %	1	

Conclusion

Considering functions and classifications of dry port, a list of nine dry port characteristics is compiled that can assist alternative development for dry ports. In addition, extensive literature review has led to the compilation of a list of 38 criteria according to which dry ports can be analysed. These criteria are divided in three categories for evaluating sustainability of alternatives: social, environmental and economic.

3 Methodology for the design, and evaluation of sustainable dry port expansion

In Chapter 3 the methodology for development and evaluation of alternatives is discussed, which is part of the first step in the design iteration. Firstly, the methodology to develop alternatives for MDP is discussed. Secondly, multiple methodologies for the evaluation of transport projects are presented. Lastly, the seven steps of the Multi-Actor Multi-Criteria Analysis (MAMCA) methodology are discussed. Which includes how evaluation criteria are selected, which weighing of the criteria is used and how the alternatives are ranked.

3.1 Method for generating expansion possibilities dry ports

In the current study, where expansion is still at an early stage, alternatives for expansion of the dry port are not yet available. Generating and defining alternatives is therefore done before the evaluation can be performed. Detailed development of alternatives for the design of MDP can be considered as a separate study and is performed by Hamburg Port Consulting (HPC) parallel to this research. The evaluation framework, and the results of the first iteration can be used to improve the layouts as they are developed by HPC. The methodology for alternative development is explained in the consecutive steps and the generation of alternatives is described in Chapter 4.

3.1.1 Alternative strategic layout development for dry ports

Different methodologies to develop alternatives for port expansion exists. The alternatives should be distinctly different and show all possible solutions for the defined problem. No standard methodology exists as this is highly dependent on the project. Two possibilities are described:

- When the key values or specific issues of the stakeholders or project are known, alternatives that take each key value into account can be generated (Zheng, 2015).
- More systematically, relevant design parameters and their characteristics can be defined which are subsequently combined to generate the alternatives.

The latter methodology is primarily applied to develop alternatives for the expansion of MDP because the key issues were unknown at the start of the research. The design parameters are

based on dry port studies (Roso et al., 2009; Villiers et al., 2013), port literature (Lami & Beccuti, 2008; Lee & Kim, 2013; Wiese, 2012; Zheng, 2015), and observations and interviews on site. For each parameter the dry port has a current state, and possible characteristics for the future. Future layouts of the dry port are determined by combining all possible states of each parameter. The main advantage of this approach is that all possibilities for the dry port will be generated. The two major disadvantages are that the number of alternatives generated is large (when the number of design criteria is large), making it impractical to review all options. In addition, the overlap between the alternatives will be substantial, as only one design parameter is altered for each alternative.

To solve these inconveniences, the two main issues at MDP are identified and alternatives are generated by improving on either one, or both of the issues. In Figure 3-1 the three alternatives are schematically depicted. Alternative 0 in the figure represents the current situation at MDP. In Chapter 4 the design parameters for MDP specific, the main issues of MDP and the expansion alternatives for MDP will be elaborated on. After establishing the three alternatives, the design criteria and their future characteristics are described for all.

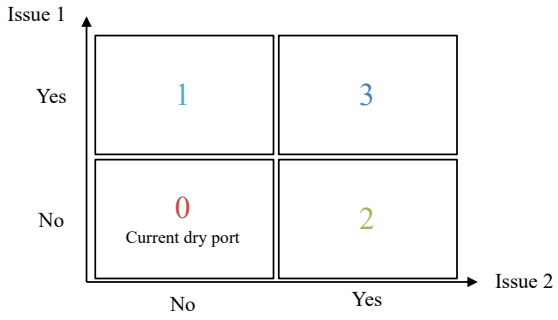

Figure 3-1. Structure of alternative development MDP

3.1.2 Throughput port demand forecasting

After the different alternatives have been established, a demand forecast should assist with determining the suitability of each alternative. Forecasting can be used for the planning of projects. Even more so than in developed economies, in Africa there is a need for adaptive and flexible design because of large uncertainties in future demand (Taneja, Ligteringen, & Van Schuylenburg, 2010). The expected demand becomes increasingly important when feasibility studies of the alternatives are performed later in the ETL project. The different scenarios for future demand are therefore not incorporated in the design alternatives, and used later by the researcher to evaluate the performance of the alternatives. The forecast is therefore used as indication only, and should be performed more thoroughly in a following study. Different methodologies to forecast cargo throughput of a port exist which are commonly classified in three models: Time series, cause-effect, and judgmental (Armstrong, 2001; Gosasang, Chandraprakaikul, & Kiattisin, 2011). Elaboration on the specifics of the methodology can be found in Appendix C.

Scenario development Modjo Dry Port

For the definition of scenarios for future cargo throughput a **cause-and-effect** model on the one hand, is combined with a **judgemental** model on the other. For the cause-and-effect model the current relation between GDP growth and container throughput development has been determined, and GDP is used as a predictor for country wide throughput. Future market share of MDP is determined using judgemental methods. In Figure 3-2 the definition of 6 scenarios for future throughput is schematically depicted.

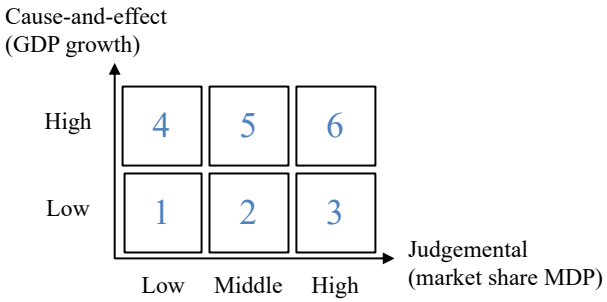

Figure 3-2. Structure of scenario development MDP

Future throughput will be estimated until 2030 because uncertainties make it difficult to plan further ahead; other documents available forecast until 2030; and according to the WB it is appropriate to plan between 5 and 10 years ahead in developing economies (Dooms, Macharis, & Verbeke, 2004). A cumulative assumption for container throughput and bulk is made together. Assumptions are made based on reports by the government and external parties, and GDP estimations. It is not supplemented with additional research.

Alternative layouts and scenario forecast for MDP are joined together to evaluate the viability of the alternatives.

3.2 Evaluation methods used in (dry) port development

The alternatives for MDP are evaluated in the next step. Multiple tools for the evaluation of transport related projects are available of which the cost-benefit analysis (CBA) and the multicriteria decision analysis (MCDA) are the most well-known and most used. They support Decision making units (DMUs) to make rational decisions by systematically analysing the possible alternatives (Baran & Zak, 2014). In the following section their characteristics and suitability for the current project are discussed. In addition, an extension of MCDA is proposed for the evaluation of MDP.

3.2.1 CBA and MCDA as evaluation methods for transport projects

Evaluation methods (post and ex-ante) for transport projects can be divided into two major categories: single criterion method (monetary values) and multicriteria analysis. The CBA belongs to the former category where MCDA belongs to the latter one.

(Social) cost benefit analysis

The CBA is the most used evaluation methodology for transport investment related projects (Beria, Maltese, & Mariotti, 2012). It compares the costs (current and future) of a project with the benefits in monetary terms. The CBA is recognized by (inter)national transport bodies and, conveniently, the methodology is comparable between the different guidelines. For example, adapted from (Ateş & Halisçelik, 2017) the following steps are defined:

1. Identification of the project, all relevant cost and benefits
2. Measurement of the monetary values of the cost and benefits
3. Analysis of cost and benefits during the life time of a project
4. Selection of alternatives based on e.g. Net Present Value, Internal Rate of Return

The performance of a CBA has a number of specific characteristics (Beria et al., 2012):

- The CBA is based on monetary values and all criteria must be (made) quantifiable
- Total benefits must outweigh the total cost to consider a project as feasible
- Point of view of a single actor

For investments of infrastructure projects, the CBA has been widely applied. In contrast, for more socially oriented projects, a CBA is less commonly used because of the difficulty in monetizing these effects (Sijtsma, 2006). An adjustment of the CBA is a social cost benefit analysis, (SCBA) in which social costs and benefits (welfare effects) are expressed in monetary terms (De Brucker, Macharis, & Verbeke, 2011). The principle of SCBA is similar to performing an CBA, scoring the alternatives on their overall cost (and benefits) and/or benefits of a project into account by monetizing the terms.

Multicriteria (decision) analysis

Like the (S)CBA, the MCDA, or MCA, is a common methodology for selecting a suitable alternative for transport projects. Stakeholders are taken into account when using the MCDA methodology, enabling emphasis on social, environmental and economic impact of the project (Beria et al., 2012; De Brucker et al., 2011). An MCDA thus enables the possibility to analyse alternatives beyond economic efficiency. As for the CBA, the aim is to systematically show which alternative is the “best” option considering a certain objective. Compared to the CBA, an MCDA is less generic, and comes in multiple forms.

The general characteristics of the MCDA are as follows:

1. Identification of decision context, the alternatives and the criteria
2. Scoring of the alternatives against the proposed criteria
3. Weighting of the criteria reflecting the relative importance to the decision
4. Selection of alternative by combining the weights and scores of each alternative

Even though this framework is followed in general, there are multiple different possibilities for the execution of the first three steps. For i2nstance, the selected evaluation criteria can differ between analyses as they can be determined by stakeholders, the project owner and/or literature. In addition to the criteria, the scoring of stakeholders and the defined groups may vary based on the objective of the project. Lastly, the methodology for determining the weight of criteria varies according to the objective and scope of the project and stakeholder group. The

subjectivity of assigning weights to the different criteria indicates that CBA is more factual by nature compared to the MCDA.

Transport related project are becoming increasingly complex and transforming all externalities to monetary values is not always possible. This resulted in increased application of the MCDA because of the possibility to rate alternatives on qualitative measures also.

Overview of the discussed evaluation methodologies

In Table 3-1 the most important differences between both methods is shown.

Table 3-1. Comparison SCBA and MCDA (Wee, Annema, & Banister, 2013)

Characteristics	**SCBA**	**MCDA**
Systematic comparison of alternatives	Yes	Yes
Explicit formulation of weights in trade-offs	Yes	Yes
Basis for weights of various effects	Valuation by consumer	Political valuation
Opportunities for abuse by policy makers	By manipulation of inputs	By manipulation of inputs and of weights
Risk of double counting	Limited	Yes
Opportunities to take into account attributes that cannot be valued in monetary terms	No	Yes
Possibility of attaching weights to the interests of specific actors	Not in the standard from of SCBA	Yes

The aim of this study is to find the most suitable expansion alternative for MDP (Modjo Dry Port) that is sustainable and in line with the interest of different stakeholder groups. This requests the possibility for a wider than simply monetary scope, the option to weigh interests of more than one actor and the option to weigh certain effects such as sustainability. In addition, data availability is scares. Table 3-1 shows that the MCDA is better suited to this study in all three regards. Especially the possibility of attaching weights to the interest of specific actors is suited for the current problem. In the next section, the importance of including stakeholders in related research is explained.

3.2.2 Multi-actor multi-criteria analysis (MAMCA) as extension to the MCDA

The importance of including stakeholders in the design and evaluation has been progressively recognized by policymakers. In the following section, literature considering stakeholder research is highlighted resulting in proposing an extension to the MCDA.

General research in strategy and management has been increasingly focusing on stakeholder theory, since the publication of (Freeman, 1984). He defines a stakeholder as *any individual or group of individuals that can influence or are influenced by the decision*. The stakeholder theory argues that, instead of considering shareholders only, they should also be involved in the decision process. Specifically to achieve port sustainability on social, environmental and

economic level, the importance of stakeholder values have been increasingly recognized by e.g. (Del Saz-Salazar & García-Menéndez, 2015; Denktas-Sakar & Karatas-Cetin, 2012; Ha, Yang, Notteboom, Ng, & Heo, 2017; J Lam, Ng, & Fu, 2013; Notteboom & Winkelmans, 2002; Vellinga et al., 2017). Most of these studies are performed in Western economies, where both sustainability, and the value of stakeholders have been widely accepted. In an African context (Slinger et al., 2017) performed a sustainability study in Ghana in which stakeholder engagement and the importance of co-creation with stakeholders is emphasized.

The following advantages of stakeholder inclusion are addressed in literature

- Stakeholder engagement is relevant from an economic perspective, because the project meets less social resistance during the construction and operation phase (Schipper et al., 2017). Port development is already complex due to the continuous operation of the site, local resistance can create significant difficulties and delays.
- Meeting the objectives of external stakeholders at the port has been considered as an key method of securing the viability of long-term port plans which may contribute to sustainable port development (Dooms et al., 2004; Jansen, Van Tulder, & Afrianto, 2018; Sakalayen, Shu-Ling Chen, & Cahoon, 2017).
- (Carbone & De Martino, 2003) recognize that the level of coordination and integration between stakeholders is an indication for the level of sustainability of the supply chain.

To conclude, the relevance of stakeholders and their interrelations have been researched extensively. However, systematically analysing the interest and vision of different stakeholders is still an issue. As addition to the MCDA, (Macharis, 2000) proposed the Multi-actor multi-criteria analysis (MAMCA) to make the interest of different stakeholder groups explicit. The methodology is explained in the next section and its preference over the traditional MCDA is elaborated on.

Multi-actor multi-criteria analysis

The MAMCA methodology is comparable to a traditional MCDA, or MCA. The main difference lies in explicitly defining different stakeholder groups and taking their point of view separately into account (Macharis, 2000; Turcksin et al., 2011). The MAMCA methodology is primarily designed for transport related problems as many different people are affected by these projects. Especially in the beginning of projects, when data is scarce, performing the MAMCA can lead to more accurate and better decision making (Keseru et al., 2016). DMUs can use the output of the MAMCA as input for their final decision making, taking the objectives of stakeholders in transport project evaluation into account (Hadavi, Macharis, & Raemdonck, 2018). The disadvantage of this methodology is that the number of participants should be relatively large to obtain reliable results and that it is time-consuming to elicit the preferences for each stakeholder group. Basically, for each stakeholder an MCA model is build which is aggregated in the final step of the methodology. (Turcksin et al., 2011) define seven steps for the execution of the MAMCA, steps 3 and 5 are substantially different from the traditional MCDA.

1. Identification of the problem and of the possible alternatives submitted for evaluation
2. Stakeholder analysis
3. Evaluation criteria choice and definition

4. Indicators for each evaluation criterion
5. Evaluation matrix to consider the importance of each criteria
6. Classification of the alternatives revealing the strengths and weaknesses of the proposed alternatives
7. Implementation of the results

In step 3, the evaluation criteria are based on the goals and incentives of the stakeholders, compared to the interest of the decision makers. Stakeholders are thus actively involved in establishing the evaluation criteria. In step 5 of the MAMCA, stakeholder groups can determine the weights of the criteria separately, where aggregated weights for all stakeholders are applied in a MDCA. Here it is important to note that the MCDA is fluid and it is possible that stakeholder groups can assign separate weights to the criteria (e.g. in (Rezaei, Wulfften Palthe, Tavasszy, Wiegmans, & Laan, 2018)). For the MAMCA the steps of stakeholder inclusion and explicit consideration of their different interest is part of the methodology which motived the choice for this method. In the following sections the methodology is explained in more detail and specific for the research considering MDP.

Methodology Modjo Dry Port expansion evaluation

In the ETLP (Ethiopian Trade Logistics Project), a number of stakeholder groups are not (yet) taken in consideration which is an opportunity for improvement of the sustainability of the project and integrate their input systematically. The MAMCA methodology therefore seems the most suitable methodology for the current project. In the initial approach there is sufficient time and resources to include a large sample of stakeholders in the study.

The MAMCA is a tool to assist DMUs with the direction of the development. It is undisputed that when commitment of the DMU is not given to the project, the results will be limited to creating awareness among stakeholders about their impact, and the value of sustainability. Whose commitment is also required to bring a significant number of stakeholders together, to educate them about sustainability and to offer security for stakeholders to give their opinion. The WB can play an important role here as they are in the position to demand a sustainability analysis from the DMU, and assist in the stakeholder analysis.

The seven steps of the MAMCA methodology are discussed in the next section. The methodology is developed in Belgium, and its application to a transport project in East Africa is new.

3.3 The 7 steps for execution of Multi-Actor Multi-Criteria Analysis

The MAMCA method specifically: "*focuses on the inclusion of qualitative as well as quantitative criteria with their relative importance, defined by the multiple stakeholders, into one comprehensive evaluation process in order to facilitate the decision making process"* (Dooms et al., 2004). The seven steps are elaborated on in this section.

3.3.1 Step 1 & 2: Identification of problem, alternatives and stakeholders

In the first step of the MAMCA the problem is defined, and the possible alternatives are suggested. The problem is defined by the WB and EMAA. Alternatives are generated based on their main issues with the current dry port (described in Chapter 4).

In the second step of the MAMCA stakeholders are identified and introduced. Stakeholder group objectives seldom converge, which stresses the importance of accurate identification of the different groups (De Brucker et al., 2011). In this section a classification of port stakeholders is made, as the type of actors are similar for sea,- and dry ports and literature about seaports is more abundant. For each project the actors are unique, and the specific stakeholders at MDP will be discussed in section 5.1.

Stakeholder groups in port development

The number of stakeholders in a port expansion project is vast and they can be classified in various ways. Most commonly a distinction is made between internal and external stakeholders. Internal stakeholders are the port authority, managers at the port, employees and shareholders (Denktas-Sakar & Karatas-Cetin, 2012). (Jansen et al., 2018; Jasmine Lam & Voorde, 2012) define external stakeholders in three different categories: market players, governmental bodies and the community. Under market players the clients such as exporters, importers and producers fall. (Dooms, 2018; PIANC, 2014b) specify contractors, technical experts, shipping agents, NGOs and the media as distinct stakeholder groups. Others assign these to the four groups mentioned before. For a clear overview of stakeholder management literature applied to ports see (Dooms, 2018). Based on the studies conducted on stakeholders in port development, the framework as in Table 3-2 considering four stakeholder groups and their objectives is deduced (Denktas-Sakar & Karatas-Cetin, 2012; Dooms, 2018; Jansen et al., 2018; Jasmine Lam & Voorde, 2012; Lami & Beccuti, 2008; Nguyen & Notteboom, 2016; PIANC, 2014b). The table provides a number of examples for each stakeholder group.

Table 3-2. Stakeholders involved in ports (Dooms, 2018; Jasmine Lam & Voorde, 2012)

	Stakeholder groups	Objectives	Examples
External stakeholders	Market players / Private companies	Improvement of port logistics conditions, improved management	Shipping companies (importers, exporters) Logistics/inland transport operators
	Public policy makers Governmental institution	Economic growth, increase in employment, improve other services, competitiveness, port capacity	Port authority Governmental institutions
	Community	Protection of the environment, avoid downgrading of pollution, economic growth, increase in employment, road safety, decongestion of road networks	Environmental department NGOs & environmental groups Residents
	Internal Stakeholders	Upgrading port capacity, safety, job sustainability	Employees Shareholders

In the context of MDP and the expansion project, the importance of stakeholders in the process is emphasized by the EMAA (DMU of the project). Governmental institutions and private companies are recognized as stakeholders, where internal and community stakeholders are not explicitly defined. Stakeholder groups of MDP should therefore be defined to get a more rounded evaluation of the expansion alternatives.

3.3.2 Step 3 & 4: Evaluation criteria for dry port expansion

In the third and fourth step of the MAMCA methodology the criteria for expansion evaluation are defined and indicators are constructed respectively. Different criteria to evaluate port performance have been used in literature. Because expansion and port project are site specific, a general framework for the evaluation of dry port expansion does not exist. The MAMCA methodology can make use of identical criteria for every stakeholder group or identify specific criteria for each stakeholder group (Turcksin et al., 2011). In this study the former method is used because of two main reasons:

- Focus is on sustainability and it is therefore for the interest of the research that all stakeholders rank the evaluation criteria specifically selected to assess sustainability
- Identifying criteria requires a certain level of awareness about possible effects of the expansion which is not generally known

Defining dry port performance is not unequivocal, as it is complex, and its meaning is different amongst stakeholder (group)s.

Selecting relevant evaluation criteria from literature

The aim of the project is to gain insight into sustainable alternatives for the expansion of MDP. To build a suitable evaluation framework for this aim, the approach used to identify and select relevant sustainability evaluation criteria involved two different approaches, based on (Antão et al., 2016)**.** A bottom-up method, where literature analysis was performed in order to assess commonly used evaluation criteria for (dry) port development, and a top-down approach, based on feedback of stakeholders via interviews and a survey on the relevance and importance of the criteria for the specific case:

1. **Developing a gross list** based on a number of boundaries and including number of references per criteria – 38 criteria (section 2.2)
2. **Stakeholder consultation** to determine importance of criteria for MDP and find additional criteria (Turcksin et al., 2011) (section 5.2)
3. Check criteria to **quality conditions** – 14 criteria (Schipper et al., 2017) (section 5.2)

In the first step performance indicators of dry ports are analysed in literature.

3.3.2.1 Stakeholder consultation: a survey

In the second step, the gross list is evaluated by stakeholders to identify which criteria are critical for dry port expansion in Ethiopia specifically. One of the key values of the MAMCA is that stakeholders' input is considered when defining the criteria. Their input is therefore highly valued in the study. In (Gohomene et al., 2016), who analysed the attractiveness of ports in West Africa, the criteria from literature were validated by four experts. Using a six-point

Likert scale, experts indicated the importance of the performance criteria, and criteria that scored lower than 3 were excluded from the analysis.

In this study, a similar approach is used to reduce the number of criteria for alternative selection of the dry port. To eliminate the criteria from the gross list that are less relevant for dry port expansion in East Africa. In comparison to the study of (Gohomene et al., 2016), a 5-point Likert scale is used to keep the possibility for a neutral score open. This validation was conducted using Google Forms and was discussed personally or digitally. For all criteria in the gross list the participants were asked to rank them between 1. Very unimportant, to 5. Very important, to quantify their opinion (Lu et al., 2016; Rodrigue & Notteboom, 2010). From each stakeholder group at least one stakeholder provided input for the validation of the criteria. Before sending, the clarity of the questionnaire was discussed with the lead economist of the World Bank involved in the ETLP. The survey can be found in Appendix C.

3.3.2.2 Quality conditions of criteria in framework

In the third step, the evaluation criteria are checked according to a set of quality conditions which help to determine whether a criterion should be included or excluded in the framework. (Schipper et al., 2017) present four quality conditions for which each criterion is scored:

- **Responsiveness**: the indicator must detect environmental, social, or economic changes in a timely way
- **Specificity**: The cause-effect relationship must be primarily responsive to human activity and show low responsiveness to other causes of change
- **Accuracy**: The accuracy of the indicator depends on whether the results are consistent for the port management plans when the indicator is used
- **Availability of data**: The indicator represented through data should be based on existing international, historically available time-series of data

In the research of (Van Der Kleij, Hulscher, & Louters, 2003) quality conditions are defined differently. To include a criterion in the evaluation framework, it must meet three conditions:

- **Minimal**: non-relevant aspects should not be included, and aspects of the decision problem should not be considered twice
- **Complete**: That means that all aspects of the decision problem should be considered
- **Non-redundant**: effects which are equal should not be considered and criteria for which the difference is small can be omitted

Quality conditions criteria evaluation framework MDP

For the evaluation criteria of dry port expansion in Ethiopia, a combination of the quality conditions is used to assign suitable evaluation criteria for the problem. Because of the small study size, it is challenging to meet the quality conditions: responsiveness, specificity, accuracy and completeness. The following three quality conditions should be met for each criterion.

1. The condition, **availability of data**, is relevant because data is commonly scarce
2. In addition, the criteria should be **minimal** and
3. **Not redundant** such that the limited number of criteria deliver significant difference in scoring

Inclusion of criteria

For the three main criteria, social, environmental, and economic sustainability, the number of subcriteria should be balanced to ensure that they are comparable. In addition, the number of subcriteria should be minimal such that weighing the criteria, and scoring the alternatives in a later stage, is feasible. Considering comparable research, the number of subcriteria usually ranges between three to five for each main criterion. In the current study, this range is maintained. The bar for inclusion of the criteria in the final framework is therefore dependent upon the responses of the stakeholders. For example, if all responses are very high, a criterion with an average of four might already be excluded from the framework because of the restriction in number of subcriteria. In addition to the input of stakeholders, the frequency of occurrences in papers is taken into consideration as are notable criteria that became apparent during interviews. The output of the questionnaire is discussed in section 5.2.1.

3.3.3 Step 5: Construction of evaluation matrix by determining weights of criteria

The fifth step is the construction of an evaluation matrix, determining the weights of the criteria of the final evaluation framework for each stakeholder group. The weight of the criteria can be allocated by any MCDA method such as Analytic hierarchy process, or AHP (Saaty, 1977) which is most popular, fuzzy methods (Rossi, Gastaldi, & Gecchele, 2013) or Best-Worst Method, or BWM (Rezaei, 2015). The latter methodology uses fewer data points compared to other pairwise comparison-based weighting methods (such as AHP), leads to more reliable results (Rezaei, 2015) and is therefore considered as a suitable option for the current study. However, weighing the criteria is rather complex because of its comparative nature, which is also true for the other methodologies. Therefore, a more straightforward method to determine the weights is used in the current study: stakeholders were asked to rank the criteria on a scale from 9 – 1. Each criterion was rated based on its importance for the development of the dry port according to the stakeholder. Weights were determined by normalising the input data.

Normalisation of data

The weighting was carried out separately for criteria within each pillar of sustainability, which subsequently received equal weight, maintaining the balance between them (Keseru et al., 2016). By means of standard rescaling (according to the minimum and maximum value of the input data) the data was translated to a 0 – 1 scale (Equation 1). This is also referred to as linear max-min normalisation method, commonly applied for MCDA methodologies (Jahan & Edwards, 2015). To increase the sample size of the study, results from the survey (for the construction of the framework) where included when determining the weights (scale: 1 – 5) and the data was normalised using the same method. The normalisation assures weights between 0 and 1 and is referred to as x'_{ij}. This step of normalisation is necessary to be able to compare the different data sets.

$$x'_{ij} = \frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}} \quad (1)$$

Subsequently, the final weights are determined using the linear normalisation sum-based method (Jahan & Edwards, 2015). This is again a common method to allocate weights for an MCDA method. Resulting in weights that add up to one for the criteria within each pillar of sustainability (Equation 2). The scores x''_{ij} are unique for each stakeholder group.

$$x''_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m}(x'_{ij})} \tag{2}$$

In addition to stakeholder group specific weights, the overall weight is calculated by taking the average of the latter weights (Macharis, De Witte, & Ampe, 2007). By varying this weight towards the overall score, the importance of different groups can be indicated. Due to the methodology of considering each stakeholder group equally, a difference in sample size will not affect the final outcome because of this variation. The sample sizes of the different alternatives are therefore not decisive for ranking the alternatives. The issues that are important for one stakeholder groups are equally valid as those indicated by another group.

3.3.4 Step 6 & 7: Classification of alternatives and implementation

In the last steps of the MAMCA methodology, in addition to concluding upon the best alternative, the preference of the stakeholder groups for each alternative is revealed. This supports the DMU in making his final decision and the positive or negative effects that this has on the different stakeholder groups (Macharis et al., 2007).

In this study the alternatives are presented to the stakeholders and experts in the field of dry port expansion. They are asked to rank the alternatives for each criterion of the final evaluation framework. For each criterion, the proposed alternative can perform negative, slightly negative, neutral, slightly positive and positive in comparison to the current situation. These results are later translated to numbers, with negative corresponding to -2, and positive to 2 respectively. The stakeholders were contacted via email, with the alternatives being proposed in an Excel sheet (Appendix E). In addition to stakeholders, a number of experts on dry port development were contacted to rank the alternatives for all criteria. Even though the experts do not have specific knowledge about the situation in Ethiopia, they are knowledgeable about the impact of the different alternative designs on the proposed sustainability criteria. The results of all evaluations are averaged and based on these scores the performance of each alternative for the different stakeholder groups is presented.

Test suitability of the methodology

Even though the methodology sounds promising in theory, and proved valuable in European transport related projects, this does not guarantee its effectiveness in Ethiopia, a country with strong grip of the government and trends in acting unilaterally. To assess whether the result of this analysis will be taken into account in the actual planning and implementation of the project around MDP, the commitment of the most powerful stakeholders should be carefully considered. Ideally, the impact of the project is twofold:

1. The evaluation framework will be used in future iterations of the design project to systematically analyse the interest of the different stakeholder groups

2. The insights from the current analysis will be used when considering next steps for the expansion of MDP

Conclusion

A suitable methodology for evolution of dry ports in Ethiopia is multicriteria based. To achieve a sustainable design, it is necessary to incorporate stakeholders in the development process. Using the MAMCA methodology to systematically deal with stakeholders is new in Africa. Stakeholders input gathered in four steps: interviews, evaluation framework, weights, and finally the ranking of alternatives.


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4 Modjo Dry Port layout and alternative generation

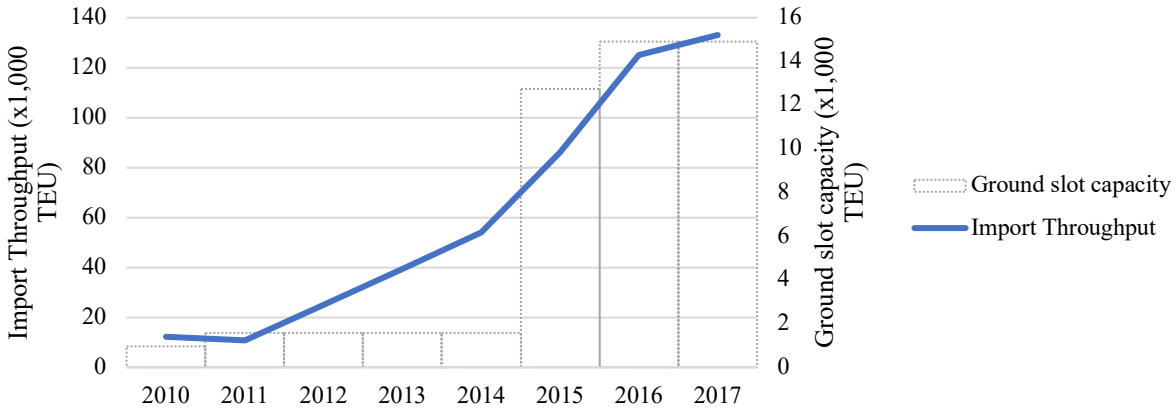
In Chapter 4 the expansion possibilities for MDP are generated and discussed, which is the second step of the design process. The current situation is assessed before generating the alternatives. Then, an estimation for future demand is made based on six scenarios. In the last section the implications for demand on the alternatives are discussed.

4.1 Case study description

In this section the current layout of MDP, which shall henceforth be referred to as alternative 0, is discussed according to the design parameters presented in Chapter 2. The information of this Chapter is based on interviews with EMAA and managers at the dry port, and observations of the researcher (five site visits). First, the characteristics associated to size are presented after which the productivity characteristics are elaborated on.

4.1.1 Size characteristics

Cargo type. The throughput of import containers at MDP was 133.070 TEU in 2017 (World Bank, 2017a) and grew significantly over the last years (Figure 4-1). The total container throughput of MDP, which includes empty handling, is disputed: it varies between ~230.000 TEU (World Bank, 2017a) and ~266.000 TEU (interview ESLSE). Containers are currently not exported from MDP nor are additional cargo, like bulk and RoRo handled at the dry port.



Ratio: TEU/ha	8,225	4,314	10,049	15,784	21,618	4,308	4,488	4,780

Figure 4-1. Import throughput and ground slot capacity of MDP since its opening. Source: (World Bank, 2017a) Note: only in 2010, 2014 and 2015 expansion of the CY took place

According to a study by EMAA, the demand for MDP is growing (World Bank, 2017a). This is in line with the historical growth in throughput of MDP, and the expected growth of total trade volume in Ethiopia. However, the historical data in Figure 4-1 show stabilizing throughput in a classic S-curve. It raises the important question of whether capacity constrains contributed to this stabilisation of throughput, or whether the demand for MDP is stabilising. This should be considered when planning for the future.

Multimodal. In 2018 the rail between Djibouti and MDP was connected, and containers are currently transported from the main seaport to the dry port via rail. There is a lack of integration of the rail: the station is on the opposite side of the gate for trucks (Figure 4-2). In addition, the station is short, which requires that the train is split in four parts before entering the dry port. V

Capacity. The capacity of a terminal or port is generally expressed in the maximum TEU (or tonnes) handled at the terminal per year. At MDP, the capacity is expressed as the maximum ground slot capacity which makes comparison increasingly complex. In theory, when MDP is exceeding the capacity, it means that the number of TEUs in the port area is larger than the ground slot capacity. The ground slot capacity is currently 12.000 (World Bank, 2017a) TEU and the capacity of the terminal is estimated between 250.000 and 300.000 TEU, based on the current throughput, occupancy of MDP, the dwell time, equipment and stacking height. Based on these figures and substantiated by the input of interviews, MDP is operating almost at capacity.

Size. MDP has an approximate surface of 73ha, of which 27ha is designated as CY (Figure 4-2 in blue). In Figure 4-1 historical ground slot capacity and CY surface is shown. Especially between 2014 and 2015 the number of ground slots expanded significantly. This growth is in contrast with the almost linear development of container throughput between 2011 and 2016. The accuracy of the historical data on capacity and size is questioned. However, the surface area of the CY is the most detailed information available and is therefore used as reference. The current layout of MDP, indicating the CY (in blue), clearance areas (open and in warehouse) offices, the gate, maintenance and a construction area is shown in Figure 4-2.

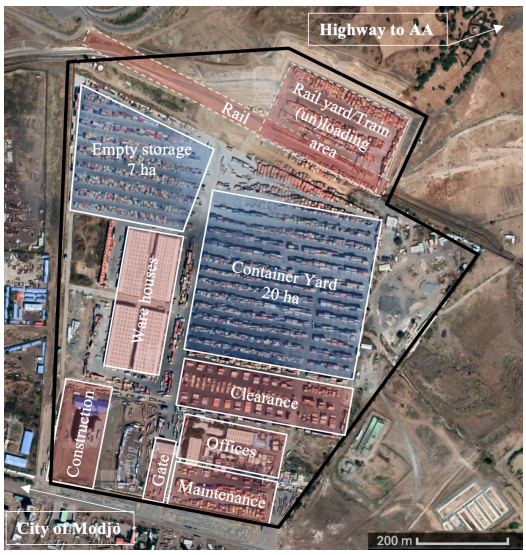


Figure 4-2. Layout of MDP (CY indicated in blue)

4.1.2 Efficiency characteristics

Value Added Services. There is a lack of VAS and other facilities for export so that there are no advantages for exporters to use the dry port. Export cargo is therefore transported to Djibouti port by truck from the production location directly. This is not possible for import containers: importers are obligated to clear their containers at MDP when they fall under the multimodal system (Appendix A). For other cargo types there is no VAS available as well.

Warehousing. Deconsolidation or warehousing facilities are only available for clearing goods. Because importers tend to want to store their products at the dry port area, and no warehousing is available, dwell times are high.

Equipment. The container yard at MDP is operated using reach stackers, of which the number is inadequate (WorldBank, 2017). Container handling with reach stackers can be improved, alternatively higher capacity equipment like RTGs can be purchased. As rule of thumb, an existing container storage yard area has a throughput of: (PIANC, 2014a)

10,000-12,000 TEU per CY hectare per annum (using reach-stackers)

In the last years, the productivity of MDP has been below 5,000 TEU per CY hectare per annum, significantly lower than the industry benchmark. This shows great potential for more optimal use of the terminal as it currently is.

ICT. The container yard (CY) does not have an automated Terminal Operating System (TOS) leading to containers being moved several times before they are ready for delivery and occasionally containers are lost in the CY (WorldBank, 2017).

Terminal infrastructure. The pavement between the rail connection and the CY is not in good condition. In general, the ground infrastructure is of poor quality (WorldBank, 2017).

These characteristics of MDP lead a to significant bottleneck: the dwell time at the terminal is currently between 50 and 60 days on average. This is caused mainly by two reasons.

1. Processes at the dry port take a long time in general, and for regular containers the dwell time is already up to 23 days on average.
2. Importers “store” their containers at MDP as storage is expensive in the capital of Ethiopia. This notion was substantiated by EMAA, ESLSE, the WB and the private companies. This results in a share of containers (approx. 20%) that is left at MDP for a significantly longer period or is not picked up at all.

Most stakeholders do acknowledge the challenges at the dry port. However, their focus of the project is mainly on growth of the dry port and diversification of goods.

4.1.3 Classification of MDP

Before providing an overview of the dry port characteristics of MDP, its classification is elaborated on briefly to position the dry port in general research.

Considering the classification based on efficiency and functions, what is being offered at MDP is relatively limited. It offers the core infrastructure and some basic logistics services such as clearance of goods. Additional services are not offered.

When considering the classifications based on size and capacity, MDP is not completely in line with the theory. Based on its distance (700km) to the seaport it is classified as a distance dry port, even though a high capacity mode was only connected recently. The latter being a characteristic of the distance port (Roso et al., 2009). Considering its location in a developing country the expectation was an export driven, or inside-out dry port, where goods are consolidated before being exported (Nguyen & Notteboom, 2016). In contrast, MDP has its full focus on import cargo, where the relevance of consolidation of goods at the dry port has been largely neglected. This has led to a trade imbalance as mentioned in Chapter 1 and shown in Appendix G.

Figure 4-3 provides a schematic depiction of the system in question. MDP imports containers via rail and road, whilst empty or full containers are exported directly from the production facility.

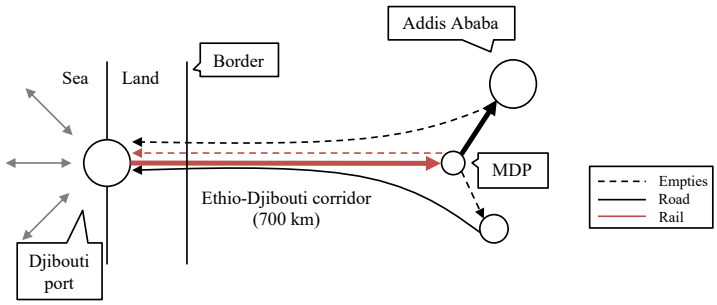


Figure 4-3. Modjo Dry Port link with Djibouti port, by road and rail

The final dry port characteristics and their state at MDP are shown in Table 4-1. In the Table three additional dry port characteristics are added based on interviews with managers at the dry port. The first is the number of people employed by the dry port (WorldBank, 2017). This measure is considered particularly important in Ethiopia where the population is growing fast. The basic idea being the more people employed, the better. An additional parameter that came up is the safety for the employees and visitors at the dry port. There are almost no measures to guarantee safety, resulting in multiple (deadly) accidents per year. Demand is added as a separate study

Table 4-1. Characteristics of Modjo Dry Port

	#	Dry port characteristics	Current situation at MDP
Size	1	Cargo type	Only container import and transport of empties
	2	Multimodal connection	Currently 4 tracks of 220m Train is split in four parts before unloading
	3	Dwell time / Capacity	The capacity of MDP lies around 300,000 TEU
	4	Size	Container yard is 25ha Total dry port 75ha
Operations	5	Value added services (VAS)	Currently not offered at Modjo Dry Port

	#	Dry port characteristics	Current situation at MDP
	6	Warehousing	No stacking equipment Only for customs, not storage
	7	Equipment	5 reach stackers 1 gantry crane (not in use) Several sizes forklifts
	8	Automation / ICT	No automation No automated container yard stacking
	9	Ground infrastructure	Multiple holes in the terminal Parts are unpaved, generating dust when windy
	10	Demand	Included as a separate study
Interviews & observations	11	Safety	Multiple accidents per year No zones for pedestrians No helmets nor fluo jackets
	12	Employment	Permanent labour: 589 Daily labour ((un)loading of containers): 576

To conclude, MDP grew significantly in throughput over the last years and demand is expected to grow in the future. However, there are currently a number of important bottlenecks that make MDP unattractive for importers and exporters. There is a large opportunity to improve upon the current state.

4.2 Strategic layout alternatives Modjo Dry Port

Strategic layout alternatives for the expansion of MDP are presented in the following section.

Initially the first approach of section 3.1.1 was used to develop different alternatives. For all design parameters (Table 2-2) the possibilities for future operations were identified. This resulted in over 10.000 alternatives for MDP. The number of parameters was brought down to five (cargo type, multimodal connection, VAS, equipment, automation/ICT) based on their need for improvement and being distinctly different. In addition, illogical and similar alternatives were deleted from the gross list, resulting in 36 possible alternatives. This number is still too large for suitable evaluation and the other method for alternative development was used (section 3.1.1).

Two trends that were raised in multiple interviews with stakeholders of MDP, with amongst others, the WB, EMAA, ESLSE and market players, considering the expansion of the port are identified as common thread of the expansion alternatives. These trends are linked to the grouping of the dry port characteristics as described in section 2.1.2 and 4.1. The two trends are:

1) The **increase in size** of the dry port to enable diversification of cargo handled at the port and increase container capacity.
2) The **operational efficiency** of the dry port should improve.

The effects of both trends are an increase in capacity and the volume of cargo handled at MDP. Based on these preferences three alternative strategic layouts for MDP have been considered. The zero alternative relates to the current operations and size of the terminal. Alternatives 1, 2 and 3 meet the main trends as shown in Figure 4-4[2].

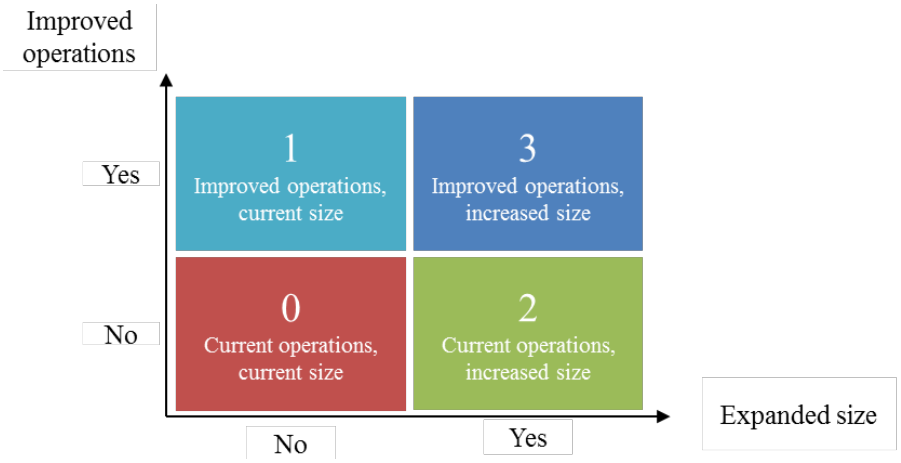


Figure 4-4. Definition of layout alternatives of MDP

Based on interviews, site visits and literature, the researcher indicated a value to the design parameters for each alternative as in Table 4-2. Measures linked to size are improved in alternatives 2 and 3, and measures linked to efficiency are improved for alternatives 1 and 3. In addition to the characteristics, a figure shows the area which is restricted for alternatives 0 and 1 (black line) and inefficiently operated (red) in alternatives 0 and 2 (Table 4-2). The table provides an indication for the characteristics of the alternatives, such that its sustainability can be assessed later. The most important assumptions for the characteristics are discussed here. The *dwell time* can be decreased to 10 – 15 days which is common in comparable countries. This directly increases the *capacity* of the dry port approximately threefold. Possible automation can increase capacity even further. The *size* can be increased majorly for alternatives 2 and 3, 100ha as additional dry port area for bulk handling is indicated. *Capacity* for bulk is dependent on the size, and can accommodate the expected demand. The number of *employees* at the dry port is expected to decrease for alternatives 1 and 3 based on the automation at the dry port. For alternative 3 people will be employed for bulk related cargo.

Table 4-2. Characteristics layout alternatives

	Alternative 0; current operations, current size	**Alternative 1; improved operations, current size**	**Alternative 2; current operations, increased size**	**Alternative 3; improved operations, increased size**
Cargo Type	Containers (import)	Containers (import & export)	All (containers, dry bulk, RoRo)	All (containers, dry bulk, RoRo)
Extending length of railway station	No	No, but handling of containers is improved	Yes	Yes
Capacity (containers)	c = ~300,000 TEU	>>> c, ~1,000,000 TEU	~ c, possibility to expand	>>> c, ~1,000,000 TEU possibility to expand

[2] The alternatives have been discussed with an associate professor at the TU Delft to increase the reliability and suitability of the proposed alternatives for expansion of MDP.

	Alternative 0; current operations, current size	Alternative 1; improved operations, current size	Alternative 2; current operations, increased size	Alternative 3; improved operations, increased size
Capacity (e.g. bulk)	0	0	500,000 tons	>> 1,000,000 tons
Average dwell time	t = ~60 days	<< t, 10 days	t = ~60 days	<< t, 10 days
Size	s = 27ha (CY)	27ha (CY)	s, possibility to expand ~100ha for bulk terminal	s, possibility to expand ~100ha for bulk terminal
Value added services	No	Yes	Some	Yes
Warehousing	2 warehouses (no storage/racks)	Racks for customs and storage	Only for customs (no racks)	Racks for customs and storage
Equipment	Reach stackers	Reach stackers	Reach stackers	Reach stackers + Gantry cranes
Automation	a = No	> a Container yard, scanning devises	a	>> a All systems automated
Improving infrastructure	No	Yes	No	Yes
Employees (with similar demand)	e = ~1,100	<< e	e, possibility to grow significantly when bulk is added	< e possibility to grow to e when bulk is added
Safety	sf = Low (multiple deadly accidents per year)	>> sf	~ sf	> sf
Layout				

The future operation of MDP is ambitious and stakeholders aim for both diversification of cargo and growth in efficiency. The alternatives are in line with stakeholders' ambitions. During interviews, it became apparent that the feasibility and the effects on the sustainability of the system of these measures have been largely overlooked. Testing the alternatives by different stakeholders for sustainability criteria will provide a first insight in a suitable alternative for the expansion of MDP.

Most stakeholders do acknowledge the challenges at the dry port. However, the focus of the project is mainly on growth of the dry port and diversification of cargo. Alternative 2 is therefore a realistic option for expansion, based on solely the interviews.

4.3 Forecast cargo throughput Modjo Dry Port

Two predictors for future throughput are used to determine distinct scenarios. They are based on the GDP of Ethiopia and the market share of MDP.

4.3.1 Ethiopian container throughput correlated with GDP

In the last years, the container throughput grew almost 1:1 with the growing economy in Ethiopia (MTBS, 2018). It is therefore assumed that the growth of container throughput will be roughly equal to GDP growth in the coming years. Economic growth in Ethiopia is currently between 8 and 10% and is expected to grow on a similar pace for the next 5 years. For the prediction a low and high growth rate are used. The high growth rate is in line with prediction until 2023 by IMF (8%). The low growth rate is comparable to economies that used to show similar growth rates as Ethiopia does now, such as Bangladesh and Vietnam (5%). In both scenarios', growth is being watered down to 5% and 3% per annum respectively from 2025: it is unlikely that GDP will keep this steady growth until 2030.

4.3.2 Market share of MDP in the future

MDP serves as a model for the development of additional dry ports operated by ESLSE. Others are in the North and the East of the country, such that MDP experiences little competition for trade volumes from Addis Ababa, and Western Ethiopia. Additionally, a number of dry ports (e.g. Kality, Endode) are located in the vicinity of Addis Ababa, closer to the market of the capital, but further from industrial parks and other production areas compared to MDP. Before MDP was selected by the WB as the dry port that would receive investment, EMAA performed an MCA on the social and environmental factors for MDP, and Endode dry port. In Figure 4-5 the resulting MCA is presented, showing that MDP is much more favourable compared to Endode. It is important to note that the claims are not support by substantial evidence or expert opinions. For the traffic flow and accident risks Endode scores lower because of its proximity to the city. Details on the scoring lacks, making it questionable how Modjo scores positive on this aspect. Modjo also scores significantly higher for its access to customers, reasoning that its location is more convenient for customers outside Addis Ababa. This is indeed true, but the advantage of Endode for customers in and around Addis Ababa remains underexposed. Endode is connected to the same railway as MDP, and there is a large interest of other (governmental) parties to operate Endode ones the multimodal system is weaved. These developments might have a significant impact on the market share of Modjo once these dry ports are operated competitively.

Parameters		Central Hub	
Category	Factors	*Modjo*	*Endode*
Social	Settlements	-2	-3
	Traffic flow and accident risks	+1	-3
	Access to customers	+3	+1
Environmental	Climate impacts	-1	-1
	Wild flora and fauna	-2	-2
	Land availability for development	+2	0
	Availability of water	+2	+2
	Availability of electricity	+3	+3
Total score		**+7**	-1
Keys: **Impact**: + Positive, - Negative; **Magnitude of impact**: 0: Neutral, 1: Low, 2: Medium, 3: High			

Figure 4-5. Multi criteria analysis for the expansion of MDP or Endode (EMAA, 2016)

In the future, heavy trucks might not be allowed in the capital because of pollution. Because MDP is rather far from Addis Ababa, goods will have to be transloaded one additional time close to the city. If this development continues it seems unattractive to import containers via MDP, which is discussed in section 5.5.

In short, there are a number of reasons why the market share of MDP might change. Its market share might increase:

- MDP might handle export containers. VAS offered at the port would attract more cargo to the port area.
- Operations at MDP may become more efficient, increasing its attractiveness. Most cargo could be sent from Djibouti to MDP directly.
- Bulk facilities might be offered at MDP to be able to handle this demand.

In contrast, there are a number of reasons why the market share of MDP might decrease:

- The market opens, other dry ports become more competitive, some of them closer to Addis Ababa.
- Heavy vehicles might not be allowed to the capital in the future. Cargo needs additional handling close to the capital.

The current market share of MDP for containers is around 40%. Expected is that the market share of MDP could decrease to 30%, stay at 40% or increase to 50% for containers, for the low, middle and high scenario respectively. MDP currently does not handle bulk which is similar in the low scenario. Bulk share is expected to increase to 20% or 30% in the middle and high scenario respectively.

In developed economies most port expansion projects are executed when demand is assured. In a fast-growing economy like Ethiopia it much more difficult to have these certainties before expanding. In contrast to developed economies, in Ethiopia the thinking goes: “when infrastructure is there, the demand will come”. As transportation costs are currently too high to export, production is low. Assuring demand for the terminal is difficult and stakeholders struggle with the scale of the expected throughput. The resulting scenarios for future demand are shown in Figure 4-6.

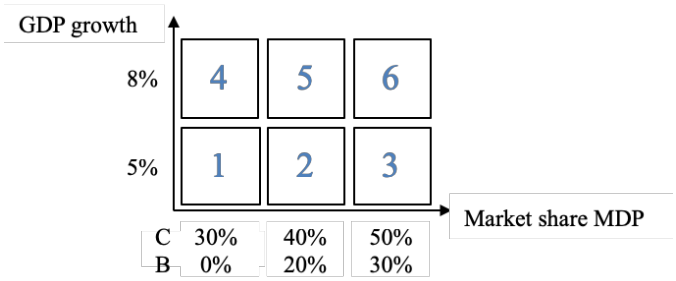


Figure 4-6. Definitions of scenarios for future demand. C = containers, B = bulk

The input for the throughput scenarios is based on the reports provided by two independent international consultancy firms, and subsequently discussed with the DMU (EMAA), the port operator (ESLSE) and the investor (WB) for verification. Initial data is obtained from Djibouti Port Authority, Ethiopian Revenue & Customs Authority and (MTBS, 2018). An overview of the current Ethiopian situation is shown in Table 4-3.

Table 4-3. Throughput of Ethiopia of different cargo types in 2017, and the market share of MDP

Cargo	Throughput ETH	Share MDP	Throughput MDP
Containers (TEU)	596,452	39%	230,000
Break Bulk (tons)	1,413,169	0%	0
Dry Bulk (tons)	2,772,247	0%	0
Cold Chain (tons)	40,872	0%	0
RoRo (tons)	198,113	0%	0

Based on the assumptions for different scenarios that are presented in Figure 4-6, and the initial data in Table 4-3, future throughput of MDP can be estimated.

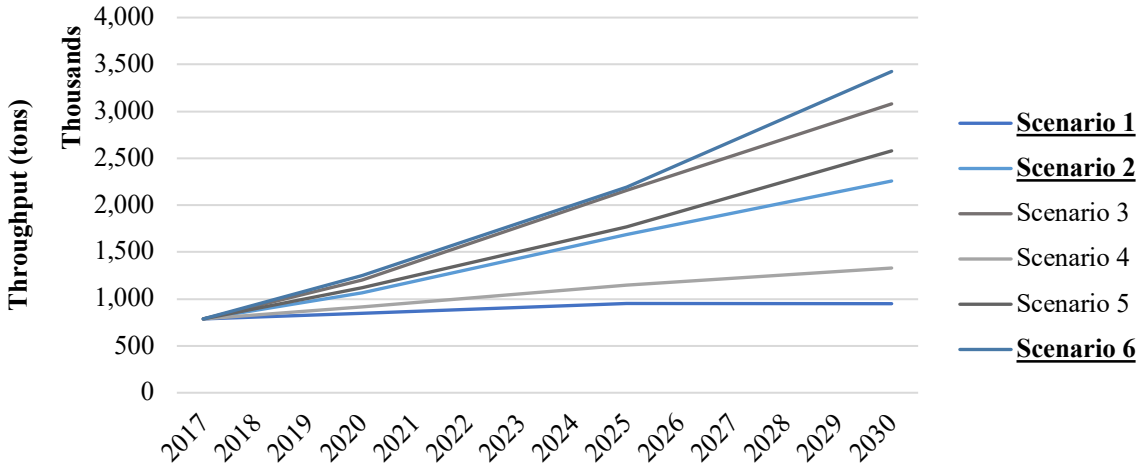


Figure 4-7. Cargo throughput (container, bulk, RoRo) MDP for 6 scenarios

Six scenarios are too many for analysis and the in between scenarios add only limited value. The minimum, maximum and a scenario in between are selected to analyse throughput. Scenario 2 or 5 are both possible as the in between scenario: number 2 is selected. For these three scenarios the split in throughput is shown in more detail (Figure 4-8).

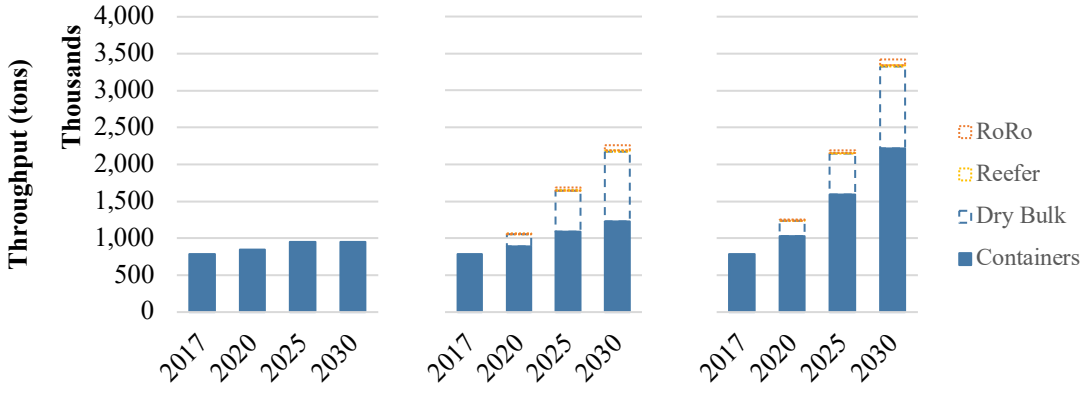


Figure 4-8. Detailed forecast for MDP (scenario 1, 2 and 6 respectively)

The container throughput for scenario 2 grows almost similarly to scenario 1, and the difference in total throughput is related mainly to dry bulk increase. In contrast, for scenario 6 there is a significant increase in both bulk and containers at MDP. The situation where containers

increase significantly (as in scenario 6), and bulk does not increase is also possible and also considered in the discussion. RoRo and Reefer containers are neglected in the remaining part of the analysis because of the small share compared to dry bulk and containers.

4.4 Combining the demand forecast scenarios with layout alternatives

In this section, the alternatives of MDP are considered according to the demand scenarios that have been defined. The alternatives are suitable only when there is a certain demand for MDP. The alternatives are placed against the three scenarios to indicate in which scenario the alternative is suitable (Table 4-4). A green yes indicates that this alternative is suitable for handling the expected demand of MDP. An orange yes indicates that this alternative is suitable for handling the expected demand for MDP at least until a certain extent.

Table 4-4. Suitability of the alternatives against the different scenarios.

	Alternative 0	**Alternative 1**	**Alternative 2**	**Alternative 3**
	Current operations, current size	Improved operations, current size	Current operations, increased size	Improved operations, increased size
Scenario 1	No	Yes	No	No
Scenario 2	No	Yes	Yes	Yes
Scenario 6	No	Yes	No	Yes

MDP cannot handle more throughput than it currently does without adaptations. If demand of the terminal would increase, dwell times will become even longer, and the constant state of congestion is expected to worsen.

Even in the minimum scenario (scenario 1) container throughput is expected to grow and thus the need to expand is high. Improving operations of the current terminal will be sufficient to handle a larger container throughput at the same surface. However, handling bulk by improving operations will not be possible. In contrast, expanding while demand is lacking is possible, but economically not viable. Alternative 2 therefore matches best with the second scenario where alternative 3 is necessary when scenario 6, a quadrupling of the throughput, becomes reality.

Alternative 1 can accommodate the growth in TEUs of scenario 2 and 6 at least until 2025, and probably until 2030. However, if this would be the aim, the primary focus should be on improving the current operations and bulk could only be handled later. This would result in a phased expansion, where alternatives 1 or 2 evolve to alternative 3 over time. The implication will be discussed in section 5.5 after the alternatives have been evaluated based on their sustainability.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5 Analysis of expansion alternatives Modjo Dry Port

In Chapter 5, the results of the seven steps of the MAMCA methodology for the evaluation of dry port expansion are discussed. The results include a final evaluation of the different alternatives for the different stakeholder groups.

5.1 Step 1 & 2: Identification of problem, alternatives and stakeholders

The problem of capacity at MDP is due to limited space (e.g. size) and to inefficient operations (e.g. equipment, ICT). Funds have been allocated to expand, but the challenge on how to do this sustainably, and meeting future demand still remains. The aim of this study is to develop a strategic design for MDP that performs well for different stakeholder groups, and takes social, environmental and economic sustainability into account.

The three alternatives for the current situation are elaborated on in Chapter 4 and summarized in Figure 4-4 and Table 4-2. After generating the alternatives, the stakeholders of MDP have been identified. In this section the level of their participation is discussed. The analysis of the results is shown in the consecutive sections.

Stakeholders groups for MDP specific

As described in Section 3.2, four stakeholder groups for dry ports are identified. Based on input of EMAA[3], a selection of private and public entities is made. Community and internal stakeholders have been identified based on research considering stakeholder inclusion (Jasmine Lam & Voorde, 2012), see Appendix G for the full list of stakeholders. The level of contact differed per stakeholder based on their availability, willingness to participate in the research, and on the phase of the research.

Response rate of stakeholders

The stakeholders were asked for their systematic input on three moments during the research. In addition, for the development of the alternatives and to understand the issues at the dry port, a number of interviews were conducted prior to the MAMCA. The resulting four moments of input are:

[3] A gross list of private and public stakeholders was provided by EMAA consisting of 365 rows for which the data of a total of 90 stakeholders are complete. To determine which stakeholders are included in the research, four randomly selected private companies in the list were contacted via telephone. It turned out that these companies did not want, or could not, comment on the developments at MDP. It was therefore decided that only overarching associations (e.g. Ethiopian coffee exporters Association) who represent larger groups of companies, were included in the set of stakeholders for the current study.

1. To analyse and understand the system interviews were conducted
   Throughout the research
2. To validate the evaluation criteria from literature for the specific situation at MDP, based on which the final evaluation framework is developed
   Section 5.3 / Step 3 & 4 of MAMCA
3. To determine the weights of each subcriterion
   Section 5.4 / Step 5 of MAMCA
4. To rank the alternatives for the expansion of MDP against the current situation
   Section 5.5 / Step 6 & 7 of MAMCA

In Table 5-1 the number of respondents for each part of the research are shown.

Table 5-1. Stakeholder groups of participants to evaluate the framework for dry port expansion

	2. Evaluation framework		**3. Weights[4]**		**4. Ranking alternatives**	
Stakeholder group	# contacted	# responded	# contacted	# responded	# contacted	# responded
Market	6	1	13	1	14	0
Governmental	6	5	11	5	9	2
Community	4	1	9	4	5	0
Internal	2	2	7	6	2	0
Expert	0	0	0	0	15	4
Total	**18**	**9**	**40**	**16**	**45**	**6**

The response rate was, especially for the later phases of the research, relatively low. Stakeholders did not recognise the importance of the research to such an extent that they were eager to participate. Stakeholder participation is a valuable tool to incorporate a broader interest in the research and warrants the sustainability of the project. At MDP, the DMU (EMAA) is an important pivot in the contact with different stakeholders. It is expected that this unilateral importance of one, or a group of stakeholders is comparable for projects in this region and lessons learned from this study can possibility be applied there.

Even though the sample size is small the results provide useful as an indicative study. The input of 16 stakeholders to indicate the weights of the evaluation criteria is a good start for a more stakeholder inclusive approach. However, the sample size is not large enough to perform descriptive statistics on the gathered data. Generally, a sample size of at least 30 inclusions is considered necessary for this purpose.

[4] For the calculation of the weights, the responses of step 2 (framework) are used to supplement the input data for determining the weights. The number of stakeholders contacted for the weights also include those contacted for the evaluation framework.

5.2 Step 3 & 4: Evaluation criteria for dry port expansion

In this section, the evaluation framework for dry port expansion in Ethiopia is constructed based on the literature study from section 3.2, and its validation by stakeholders.

5.2.1 Results from survey stakeholders for the selection of criteria

From each stakeholder group at least one person participated in the validation of the evaluation criteria (Table 5-1). The selection of the criteria for the final framework is done as follows:

- The three criteria found most important by the stakeholders are selected for the framework (with the exception of one criterion due to repetitive feedback of stakeholders)
- A maximum of two additional criteria are selected: when the criterion is highly cited in literature or when the criterion became apparent in interviews
- The criteria should meet the quality conditions of availability of data, minimal criteria and not redundant (section 2.2)

No general line on the average score by stakeholders can be drawn because scores varied between the main sustainability indicators (social, environmental and economic). For the framework, all pillars should have a comparable number of criteria, their importance becomes apparent when weighing the criteria.

To determine the final framework both stakeholders and literature have been consulted. However, scoring was rather comparable between the different criteria and deciding between inclusion and exclusion is therefore based on a fine line. A larger sample size could increase the statistical power of the small differences. The data do provide acceptable assumptions.

Social sustainability related criteria

In this section the social sustainability criteria as in Table 2-3 are substantiated by the indicated importance by stakeholders. A selection of criteria for the framework is also made.

The framework is specifically designed for dry port expansion in Africa, which is significantly different than expansion projects in more developed regions such as Europe. This leads to a number of discrepancies between literature, which is mainly focused on developing regions, and the current research. Population in Ethiopia is growing fast, the unemployment rate is high, and labour is inexpensive (World Bank, 2018a). Creating work is therefore desirable, where reducing the number of employees is economically more attractive in developed countries. Based on this, employment is considered as a social factor instead of an economic factor. This choice is backed by 9 of the papers that where reviewed. In Table 5-2 the criteria related to social sustainability are shown and the criteria selected for the evaluation framework are highlighted.

Table 5-2. Social criteria from literature for the evaluation of (dry) port development. The criteria in bold are selected for the final framework (SH = average score stakeholder; # of ref = number of citations in selected papers; QC = quality condition)

Criteria	# of ref	SH (n=9)	Note
Employment generation (direct and indirect)	9	4,7	Found important by stakeholders
Resettlement of local community	5	4,7	Found important by stakeholders
Education of local community	5	3,6	QC: Availability of data
Safety: Traffic (for community)	5	4,1	Safety in general is considered
Heritage and cultural impact of the expansion	4	3,3	Not considered important by stakeholders
Visual intrusion due to the port developments	4	3,3	Not considered important by stakeholders
Quality of living for community	3	4,4	QC: Availability of data
Safety: Employees	3	4,7	Found important by stakeholders
Working environment	2	4,5	QC: Minimal with safety
Safety: Diseases (like malaria and STDs)	2	4,4	Safety in general is considered
Economic equality: opportunities for underprivileged	2	4,4	QC: Availability of data
Institutional, legal and political stability for port employees and the local community	1	4,1	QC: Availability of data
Stakeholder consultation: before, during and after expansion	1	4,9	Found important by stakeholders
Gender equality	1	4,4	QC: Non redundant
Dust	-	-	Emerged during interviews with employees

The social criteria that are included in the evaluation framework are: stakeholder consultation, employment generation, safety, resettlement of local community and dust generation. These relate to the 8th sustainable development goal (SDG) of the UN which is *Decent Work and Economic Growth*. The latter criterion, dust, has been indicated in direct conversation repeatedly by workers at the terminal and is therefore included in the framework. This criterion was added only after validating the framework with stakeholders as its perceived importance arose after the primary meetings. Safety collectively implies protection for the employees, from traffic and diseases, all considered important by stakeholders. The remaining three criteria are considered as highly important by stakeholders. Other criteria, such as education, are not included because they receive a lower score by stakeholders or do not confirm to the quality conditions (see Table 5-2 for note on exclusion of criteria).

Environmental sustainability related criteria

In this section the environmental sustainability criteria as in Table 2-4 are substantiated by the indicated importance by stakeholders. A selection of criteria for the evaluation framework is also made.

Environmental issues are less obviously present when considering land projects compared to sea projects. Identifying the most important criteria that will affect environmental sustainability at MDP is still relevant. In Table 5-3 criteria related to environmental sustainability are shown and the criteria selected for the evaluation framework are highlighted.

Table 5-3. Environmental criteria from literature for evaluation of (dry) port development. Criteria in bold are selected for the final framework (SH = average score stakeholder; # of ref = number citations in selected papers; QC = quality condition)

Criteria	# of ref	SH (n=9)	Note
Minimising emissions	14	4,2	Highly cited in literature
Minimising energy use & energy source (renewables etc.)	7	4,3	QC: Minimal with emissions
Waste management (recycling and hazardous goods handling)	6	4,6	Found important by stakeholders
Protection of land and natural environment	6	3,9	Cited - not included when determining weights
Noise pollution	4	4,0	Indicated by employees at the dry port
Light pollution due to 24h operations	2	3,0	Stakeholder did not consider this as important
Minimising climate change	2	4,0	QC: Minimal with emissions
Existence of environmental programme	2		Not applicable for the current situation
Soil pollution due to activities of the dry port, and industries around	1	4,1	QC: Minimal with protection of land

The environmental criteria that are included in the evaluation framework are: waste management, minimising emissions, noise pollution and protection of land and natural environment. These relate to the 12th and 15th SDG by the UN which are *Responsible Consumption and Production* & *Life on Land.* Minimising energy use was not included in the analysis because stakeholders perceived this criterion as similar to minimising emissions. The quality condition minimal was therefore not met. The decision on which criteria to include was based on number of citations in literature. Noise pollution was indicated by the employees of the terminal as an important measure and is therefore also considered in the evaluation framework. The criterion protection of land, and the criterion soil pollution were perceived as similar and the criterion that was more often cited in literature was selected for the evaluation framework.

Economic sustainability related criteria

In this section the economic sustainability criteria as in Table 2-5 are substantiated by the indicated importance by stakeholders. A selection of criteria for the framework is also made. A wide range of economic criteria are considered, and the gross list is therefore extensive. In Table 5-4 the criteria related to economic sustainability are shown and the criteria selected for the evaluation framework are highlighted.

Table 5-4. Economic criteria from literature for the evaluation of (dry) port development. Criteria in bold are selected for the final framework. (SH = average score stakeholder; # of ref = number of citations in selected papers; QC = quality condition)

Criteria	# of ref	SH (n=9)	Note
Maximising value-added services	7	4,8	
Transport cost & time	7	4,6	
Income and profit dry port	5	3,9	Considered less important by stakeholders
Productivity port area (TEU per ha/equipment/employers)	5	4,9	
Total throughput port area	5	4,4	
Investment cost	5	4,4	QC: Availability of data
Safety: cargo handling (for products)	5	4,6	QC: Minimal - reliability of service
Accessibility of multimodal transport options	4	4,9	
Customs clearing efficiency	4	4,4	QC: Availability of data
Employment	3		Considered under social sustainability
Range of value-added services	2	4,7	QC: Minimal - maximizing VAS
GDP generation (local and country)	2	4,4	
Congestion on main leg and in port area	2	3,9	Considered less important by stakeholders
Reliability of service	2	4,7	
Automation	2		Included as design parameter
Market share %	1		QC: Availability of data

The economic criteria that are included in the evaluation framework are: productivity, multimodal transport, maximising VAS, reliability of service and transport cost & time. These relate to the 8th and 9th sustainable development goal which are *Decent Work and Economic Growth & Industry, Innovation and Infrastructure.* The number of citations in literature is comparable between the different criteria. The seven criteria that have received a stakeholder score of 4,5 or higher are primarily considered. The criterion range of VAS is not minimal with maximizing VAS and is therefore not considered as a separate criterion. Safety has already been included as a social criterion and is therefore not included as economic measure. The criteria total throughput, GDP generation and income/profit of the dry port were not mentioned in interviews and are therefore not included in the evaluation framework.

5.2.2 Summary: evaluation matrix dry port expansion in Ethiopia

In summary, when considering the most important subcriteria for the three main criteria: social, environmental and economic sustainability, the evaluation framework of Table 5-5 can be constructed. Some evaluation criteria are similar to the dry port characteristics identified in

section 2.1. However, this does not present difficulties in the analysis as there is no analytical relation between the two list.

Table 5-5. Final framework for the evaluation of dry port expansion in Ethiopia (own work)

Pillars	Subcriteria	Measurement unit
	Employment	Number of employees
	Resettlement of local community	Absolute number of people mandatory displaced
	Safety	Total accidents and causes
	Stakeholder consultation	Input of different stakeholder groups
	Dust	Particles in atmosphere
	Minimising emissions	Emissions per TEU
	Waste management	Ratio recycled vs burned waste
	Protection of land and natural environment	Estimation by expert
	Noise pollution	For community, employers - Estimation by expert
	Maximising value-added services (VAS)	The value per tonne of port cargo added in MDP
	Transport cost & time	Expressed in dollars and hours
	Productivity	TEU per ha/equipment/employers
	Accessibility of railway	Proximity, capacity, freq. – estimation by expert
	Reliability of service	For customers – percentage of shipments that arrive at their final destination on time

A summary and implication of the criteria is provided in the following section.

Social. The criterion *employment* encompasses both direct, and indirect employment generated for the different alternatives. Under indirect employment fall industries around Modjo, labour created in the transport sector and industries that can expand due the developments around the dry port. *Stakeholder consultation* implies increasing awareness and participation of the public during the whole process. In this framework *safety* is a broad concept capturing the (un)safety for residents caused by vehicles on the road, safety for employers due to the machinery, training and equipment. Lastly, the safety of the community for diseases, such as malaria and STDs, are grouped under this subcriterion. *Resettlement of the local community* could be a consequence of dry port expansion when farmers in the vicinity of MDP have to be relocated. In an earlier expansion a significant number of farmers was faced with mandatory relocation, which was perceived negatively despite financial compensation. The last criterion, *dust,* considers the amount of dust generated at the terminal, which is inconvenient for employers as well as the community. Due to high winds and inadequate pavement, a large amount of dust is generated at the terminal area causing health problems for the community and employees.

Environmental. The criterion *minimising emissions* encompasses all greenhouse gasses emitted by cargo transport. The criterion *waste management* consists of two components, the recycling rate of plastics, and papers at the terminal, and the handling of hazardous goods. In port areas *noise pollution* can have a negative effect on the environment

when the site becomes uninhabitable for animals. In dry port areas these effects are from truck honks and possible 24/7 operations of MDP and related industry. The criterion *protection of land and natural environment* issues that the environment will be protected when expanding MDP.

Economic. The criterion *productivity* of a terminal amount of cargo handled per resource usage such as labour and equipment. The criterion *transport cost & time* is a measure that includes a larger part of the supply chain and is linked to the transport mode. For MDP goods can be transported by rail and road. The criterion *maximising VAS* includes, among others, packing and labelling at the dry port area. The *reliability of service* at MDP entails the on-time delivery of goods. defined in terms of the percentage of shipments that arrive at their final destination on time (Liu, 2016). The last economic factor is *accessibility of railway* indicating that multimodal transport is a suitable option compared to road transport. In this study accessibility to multimodal transport is replaced by railway because of the uni/multi modal transport system that is in place in Ethiopia.

Conclusion

To conclude, in this study a framework for the evaluation of dry port expansion was developed that covers both the most important criteria from literature, and was tailored for the specific situation in Ethiopia by including the input of a broad spectrum of stakeholders. For each pillar of sustainability, four or five subcriteria were selected for the evaluation of the expansion alternatives of MDP. This resulted in a framework with 14 subcriteria.

Notable criteria for evaluation of dry port expansion in Ethiopia are listed below.

- *Employment* – which is promoted in Ethiopia whereas labour is a significant expense in developed economies and is therefore minimised.
- *Stakeholder consultation* – is included because of its high score by participants. It is not common to include in other studies, however, because of emphasis of the DMU on stakeholder integration the criterion is included.
- *Productivity* – is rated as important, which is not in line with the current operations, nor with the aim to employ many people, nor with the desire to expand to different cargo segments soon.

5.3 Step 5: Weights of criteria the evaluation matrix

In the 5th step of the MAMCA the criteria are determined for the different stakeholder groups at MDP. No clear minimum on the number of stakeholders included in a project is provided, but generally: the larger the better. Gathering the weights from stakeholders was challenging, and the final weights are inconclusive. The weights have been determined based on the input of 16 stakeholders. This led to an indication of the preference of each criterion, which is sufficient in this stage of the project, where stakeholders are learning about the effects of dry port expansion.

Governmental and market players considered as one group

Governmental and private parties are combined in the research because of the low response rate of market players. In addition, this can be done because their collaboration is already present and because the users' and operators' objectives considering sustainability are expected to be relatively similar. The governmental institutions are actively trying to incorporate the opinion of the private companies in the project and the WB is also pushing this relation. Their input is therefore expected to be relatively aligned. Nonetheless, in future projects the stakeholder groups should be split to research whether differences between the groups exist. This could be achieved by organising a workshop for all stakeholders.

5.3.1 Aggregated weights of evaluation criteria for the stakeholder groups

Social, environmental and economic sustainability are all equally important in achieving sustainable expansion of MDP. The three pillars therefore all receive a weight of 1/3.

Within each pillar of sustainability, the weights of criteria have been determined by multiple stakeholders. They were asked to indicate the best and worst criteria for each sub set of criteria after which they expressed to what extent they prefer the best criterion over all other criteria. The data was normalised using linear min-max normalisation and weights have been determined using sum-based normalisation (section 3.2).

Weights of the evaluation criteria for all stakeholders

The overall weights (average of groups) of the evaluation criteria are shown in Table 5-6. Stakeholders tend to value the evaluation criteria as equally important. There are a number of exceptions, but especially the homogeneity of the weights stands out. For example, the economic criteria all receive comparable weights when all the average of all stakeholder groups are considered. For the social criteria, only dust received a very low score compared to the others. For the environmental criteria minimising emissions and waste management were considered more important compared to protection of land and noise pollution.

Table 5-6. The 14 core criteria grouped under the three pillars of sustainability and their overall weights (n=16)

Social	**0,33**	**Environmental**	**0,33**	**Economic**	**0,33**
Employment generation	0,23	Minimising emissions	0,31	Maximising VAS	0,23
Resettlement	0,21	Waste management	0,33	Transport cost & time	0,20
Safety: Employees	0,23	Protection of land	0,14	Productivity port area	0,18
Stakeholder consultation	0,25	Noise pollution	0,22	Multimodality	0,20
Dust	0,08			Reliability of service	0,19

Unexpected is the equal importance of stakeholder consultation to employment generation as the latter only became more apparent during the interviews. The criteria productivity and employment are both considered important by stakeholders. This is noteworthy, as they are contradictory: an improvement in productivity of the port area is usually accompanied by a decrease in the number of employees. However, for MDP employment should be kept stable or increased, according to the stakeholders. The DMU of the expansion project in Modjo, should consider these contradictory measures carefully when deciding to increase productivity,

or when employing more people. As part of the MAMCA methodology the weights are also visualized for each stakeholder group separately.

Weights of the evaluation criteria for the stakeholder groups

The weights for each criterion, and each stakeholder group is visualised in Figure 5-1. A large difference in weights between stakeholder groups was expected based on existing stakeholder studies and on the interests of the different groups. Interestingly, the weights only show small fluctuations between the groups. The analysis implies that the interests of different stakeholder groups are close together, increasing the ease to find a solution that is acceptable for all groups. However, because of the limited sample size, no significant conclusions can be drawn from this analysis.

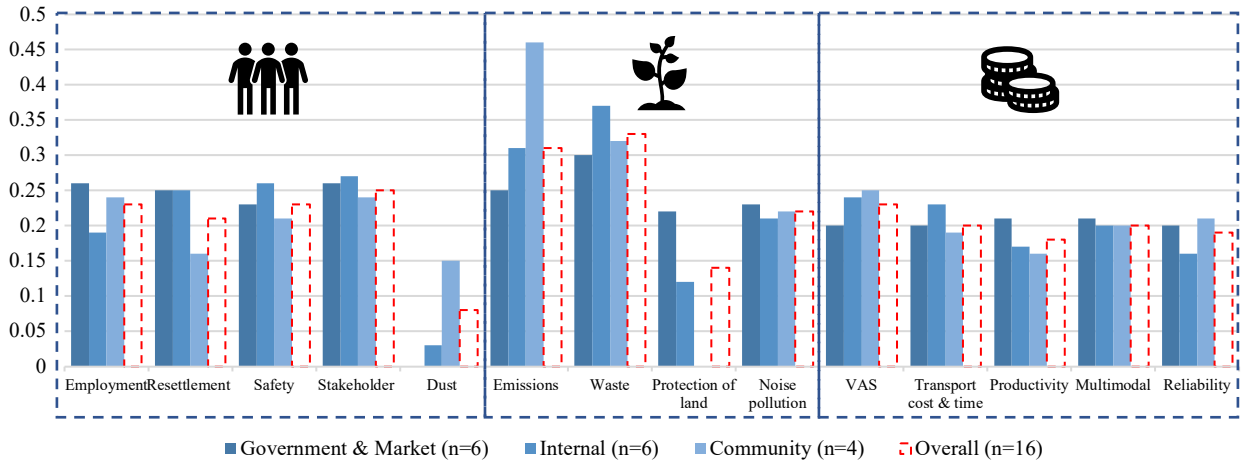


Figure 5-1. Weights of the subcriteria of the different stakeholder groups

Again, the homogeneity for the economic criteria stands out immediately. Stakeholders indeed indicated that they considered all criteria as very important, this resulted in limited fluctuations between the scores.

To differentiate between the alternatives, differences in weight are required to draw a conclusion on the most suitable alternative. If all criteria are perceived equally important, a straightforward SCBA would suffice for the analysis (Section 2.2). However, based on earlier research considering sustainable port development, and transport projects in general, it is known that stakeholders do have different interest and views on the process.

Different reasons for the outcome of this analysis can be considered:

- Educational purposes – stakeholders are unaware about the implications of the criteria
- Coincidence – sample size is too small
- Complexity of weighing methodology – stakeholders found it difficult to weight the criteria relative to each other
- These are the true values and differentiation between stakeholder groups is much smaller in an Ethiopian context

To rule out the first three reasons, a study that pays more attention to education of the stakeholder groups, includes a larger sample and simplifies the weighing methodology should

be performed. For the current study final scores of the alternatives are determined using the weights as obtained.

5.4 Step 6 & 7: Classification of expansion alternatives

In step 6 and 7 the overall ranking, and the differences between stakeholder groups is revealed to conclude upon the aggregated best alternative for MDP expansion.

5.4.1 Comparing the alternatives using the evaluation framework

Stakeholders of MDP and experts were asked to rank the alternatives according to the evaluation framework. For each criterion, the participant was asked whether the alternative performed negative (-2), slightly negative (-1), neutral (0), slightly positive (1) and positive (2) in comparison to the current situation. The average scores for each alternative, and each criterion is shown in Figure 5-2.

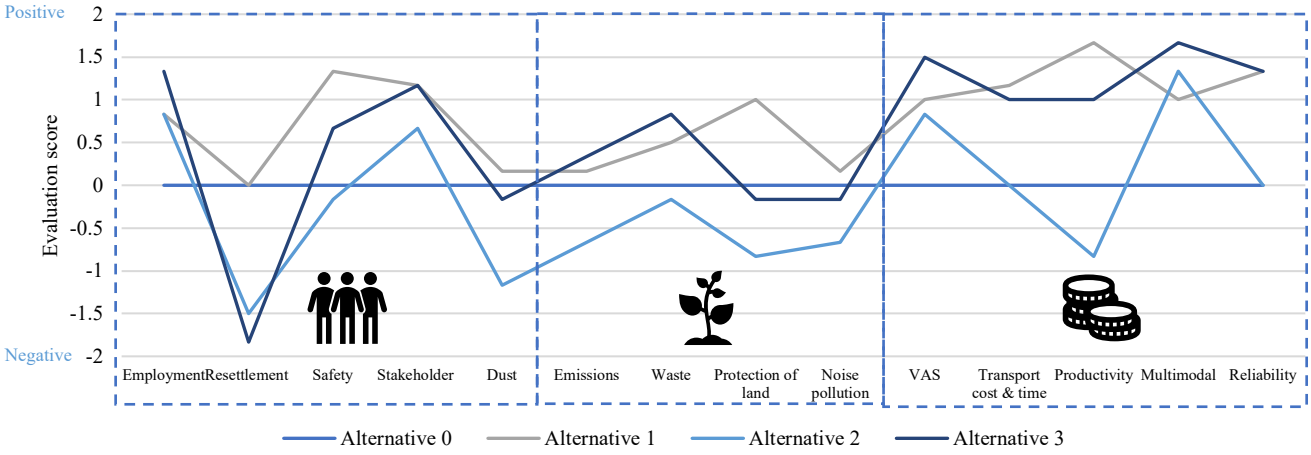


Figure 5-2. Performance of the alternatives against the current situation indicated by stakeholders (n=2) and experts (n=4)

Before applying the weights, it can be observed that alternatives 1 and 3 perform better on most criteria compared to the alternatives 0 and 2. Additionally, interesting is that alternative 1 performs equal or better for all criteria compared to the current situation, alternative 0. For each pillar of sustainability, the most notable scoring is discussed briefly.

Expansion in size reflects negatively on the possible *resettlement of the local community*, an expected negative trait of alternatives 2 and 3. Unexpectedly, alternatives 1 and 3 score well for *employment*, even though less people are expected to be employed due to increasing automation. It is possible that experts were unaware of the situation that over 1000 people are currently employed at the dry port and it could have been more explicitly mentioned in the questionnaire (Appendix E). The issue of decreasing need for employment when automation increases, was discussed with the municipality of Modjo, and with the dry port operator. Both stakeholders do expect that there will be sufficient work for “daily labour” and employment levels only go up. Alternatively, experts and stakeholders could have reasoned that growing throughput would lead to additional services at the dry port and employment level will increase.

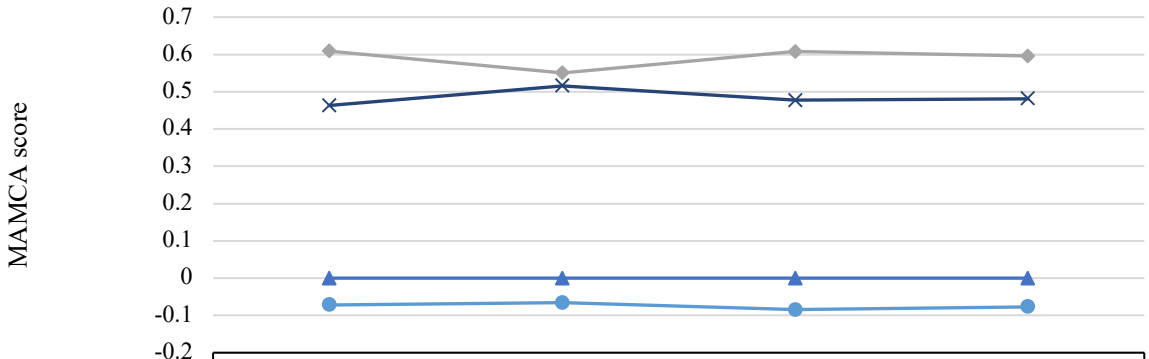
The "positive" score for *emissions* is more difficult to explain. In general, it is questionable whether alternative 1 would perform better related to the current situation considering *minimising emissions*. Transportation by rail and more efficient handling will contribute to decreasing emissions of the current throughput. However, when throughput would triple, total emissions of the terminal might increase. *Waste management* scores positive for alternatives 1 and 3 and negative for alternative 2, in line with expectations.

For the economic pillar all alternatives score positive compared to the current situation. This is in line with the expected growing demand for MDP and the need to invest in the dry port. The only exception to this is the *productivity* of alternative 2, which scores much lower compared to the current situation.

Even though it is common that experts and stakeholders rank the alternatives according to the evaluation criteria, quantified scoring would be valuable for the current situation. For example, an estimation on the amount of emissions and employees for the different alternatives can be made. In a later stage it is expected that more data will be available and for most evaluation criteria an estimated effect for each alternative can be made. The quality of the ranking would then improve.

5.4.1.1 Aggregated best alternative of MDP

The final output of the MAMCA is a multi-stakeholder view that displays the preference of each alternative for all groups in which the scores are multiplied by the weights (Figure 5-3). Similarly as before applying the weights, alternative 1 is the aggregated best alternative for all stakeholder groups, with alternative 3 as a very close second. Alternative 2 clearly performs worse for all stakeholder groups.



	Government & Private (n=6)	Community (n=4)	Internal (n=6)	Overall (n=16)
Alternative 0	0	0	0	0
Alternative 1	0.61	0.55	0.61	0.60
Alternative 2	(0.07)	(0.07)	(0.08)	(0.08)
Alternative 3	0.46	0.52	0.48	0.48

Figure 5-3. Overall result MDP expansion alternatives

The main take away of this result is that only expanding in size is a less sustainable solution than improvement of the current operations, which is similar for all stakeholder groups. The result is highly valuable for the DMU because it shows which criteria are important to consider for the expansion. In Table 5-7 the performance and overall weight of each alternative for each evaluation criteria are shown.

Table 5-7. Performance of the alternatives considering all stakeholder groups (may not add up to one due to rounding)

	Evaluation criteria	Overall Weight	Alternative 1		Alternative 2		Alternative 3	
			Rank	Score	Rank	Score	Rank	Score
Social (0,33)	Employment	0,23	0,83	0,06	0,83	0,06	1,33	0,1
	Resettlement of local community	0,21	0	0	-1,5	-0,11	-1,83	-0,13
	Safety	0,23	1,33	0,10	-0,17	-0,01	0,67	0,05
	Stakeholder consultation	0,25	1,17	0,10	0,67	0,06	1,17	0,1
	Dust	0,08	0,17	0	-1,17	-0,03	-0,17	0
Environmental (0,33)	Minimising emissions	0,31	0,17	0,02	-0,67	-0,07	0,33	0,03
	Waste management	0,32	0,5	0,06	-0,17	-0,02	0,83	0,09
	Protection of land and natural environment	0,14	1	0,05	-0,83	-0,04	-0,17	-0,01
	Noise pollution	0,22	0,17	0,01	-0,67	-0,05	-0,17	-0,01
Economic (0,33)	Maximizing (VAS)	0,23	1	0,08	0,83	0,06	1,5	0,12
	Transport cost & time	0,20	1,17	0,08	0	0	1	0,07
	Productivity	0,18	1,67	0,10	-0,83	-0,05	1	0,06
	Accessibility of railway	0,20	1	0,07	1,33	0,09	1,67	0,11
	Reliability of service	0,19	1,33	0,08	0	0	1,33	0,08
	Total score			0,60		-0,08		0,48

5.4.2 Sensitivity analysis of MAMCA

After ranking the alternatives, it is tested whether with small changes in the input the output changes. The purpose of a sensitivity analysis is to determine the degree of variation needed in the original data and weighting to cause a change in ranking. Because of the small sample size of the current study no formal sensitivity analysis can be performed. However, the possible methodologies to increase the confidence of the analysis are discussed. For the MAMCA methodology two sensitivity analysis are common to perform:

Considering the weight of the stakeholder groups

A sensitivity analysis for the MAMCA methodology typically entails varying the importance of the stakeholders towards the "final" aggregated alternatives (Hadavi et al., 2018; Macharis et al., 2007). This is especially relevant when some stakeholder groups are less important than others. In the current study it would have been interesting to increase the weight of the DMU and of the WB, or increase the weight of the community and internal stakeholders to better understand their preferences. The results can be used to identify possible bottlenecks. However, as the stakeholder groups in the current study are relatively aligned in their interest, this analysis will not provide to an additional view.

Considering the weights of the criteria

The value of the weights can also be altered to assess the rigidness of the input data (Hadavi et al., 2018; Oosterwegel, 2018). For example, the weights can be altered with +20% and -20%

to validate whether the alternatives are still valued similarly. In the current study, without assigning weights to the 14 evaluation criteria, the alternatives score very different (Table 5-8). In the table it shows that alternatives 1 and 3 score superior compared to alternative 2 (and alternative 0 which scores 0). With weights that are almost homogeneous, increasing or decreasing those with 20%, the same ranking is obtained.

Table 5-8. Total score of alternatives (when no weights were assigned to the criteria)

	Alternative 1	Alternative 2	Alternative 3
Overall (n=6)	**0,8**	**-0,2**	**0,6**
Stakeholders (n=2)	0,5	0	0,6
Experts (n=4)	1	-0,3	0,6

5.5 Discussion of results

Outlook and policy implications

The study was conducted to present a methodology that can improve the sustainability of port related projects in East Africa. In this specific project the sustainability of a dry port expansion in Ethiopia has been evaluated by systematically incorporating stakeholders into the process. Because a similar study has not yet been conducted in this region, the results require a strong discussion, so that future research may benefit from, and improve upon it. In this section, the consequences and implications of the outcome of the study for the DMU of MDP is discussed. In addition, the demand analysis is discussed, and the possible network implications are indicated. Furthermore, the stakeholder participation is critically reflected upon, and implications for the results of this study are highlighted. Lastly, the most important new insights of the researcher are briefly mentioned.

Implication of results for DMU

From the analysis it shows that alternative 2 performs significantly less on sustainability compared to alternatives 1 and 3. Based on this finding the focus for MDP expansion should primarily lie on improving current operations before expanding to new cargo types and new services. This is interesting because in interviews stakeholders indicated alternative 2 as the most likely direction for expansion. This raised several questions concerning amongst others the consciousness of efficiency implications, the accuracy of the description of the alternatives, and the suitability of the evaluation framework.

Efficiency implications and alternative description. Improving efficiency in African ports is a recurring topic in literature (e.g. Gohomene et al., 2016). It may look like low hanging fruit, as no additional land is required for the improvement. Additionally, it is a sustainable alternative, as follows from the analysis. However, the road to a more efficient dry port is rather complex, and it requires a high level of commitment from all parties involved. The dry port has held a monopoly and operational efficiency has not been prioritized. As such, it seems that most stakeholders are preferring expansion of the dry port area rather than improving the current operations, contradicting with the outcome of the study. To overcome this gap, the

evaluation criteria and dry port characteristics are reflected upon considering alternative 2. Four evaluation criteria are highlighted for which alternative 2 was scored lower compared to the other alternatives (Table 5-6). *Resettlement of local community* and *protection of land* are criteria that can be improved also for alternative 2 when being handled carefully. More difficult to improve are the criteria *productivity* and *transport cost and time* as sincere devotion and effort is required to improve these measures (World Bank, 2017a). In addition, two dry port characteristics are highlighted for alternative 2 that can be improved within the boundaries of the alternative (Table 4-2). *Dwell time* can be decreased slightly with a certain level of commitment and offering of warehouses. This would result in a higher score for productivity and transport cost & time. *ICT* improvement by providing a basic level of TOS can be used in the yard improving upon the same criteria as dwell time decrease.

Suitability of evaluation framework. In the current analysis the three pillars of sustainability have been considered equally. However, when asking the stakeholders, a clear preference for social and economic factors arose (Figure 5-4). This contrasts with the findings in literature, where environmental issues are highly cited. It is also different from the emphasis of the SDG defined by the UN on environmentally sustainable development (UN, 2018). On the other hand, social sustainability criteria are highly valued, which is different compared to existing research on port performance indicators (e.g. (Keseru et al., 2016; Rezaei et al., 2018)). This indicator might be highly valued in developing countries in general, where caring for the community is more common in comparison with developed countries. However, this is not confirmed nor found in other studies. When using the weights of Figure 5-4 to determine the performance of the different alternatives the results are comparable to the base case, with a slight decrease in difference between the alternatives. The lacking interest of community and internal stakeholders for environmental factors is notable and important to consider. In addition to actual lack of interest, the stakeholders might be not well educated or do not feel in the position to give an opinion. To achieve sustainability, all pillars should be included to a certain extent. Whether this part should be equal is disputed in literature.

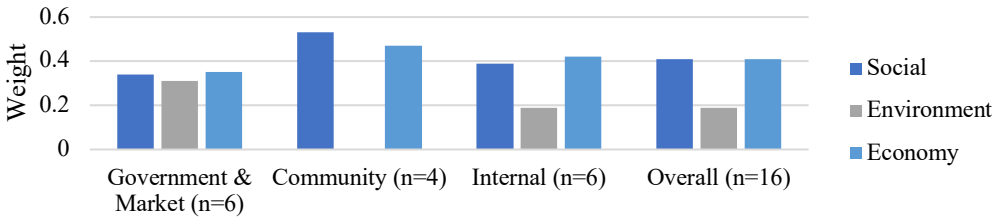


Figure 5-4. Weight of the main evaluation criteria indicated by stakeholders

In addition, the accuracy of the evaluation framework is questioned because of two main reasons. The number of stakeholders to verify the most important criteria was small, and their scoring did not provide significant values. More importantly, costs are only included limited in the economic criteria (transport cost and time) whereas the DMU will make a decision based on cost mainly. Expanding in size rather than improving operations might be more economically attractive because of the relative low cost of land in Ethiopia. When constructing the framework, criteria as investment cost and revenue/profit of MDP were not included based on the stakeholder score and the limited data availability. This is however an interesting addition to the current evaluation framework.

Possible demand implications

To ensure sustainability, in addition to ranking the alternatives according to the evaluation framework, the alternatives should be future proof (e.g. a very sustainable dry port with zero throughput is still less sustainable than no dry port at all). The throughput of MDP seems saturating, however, a growth in throughput is expected when capacity at MDP is provided. In general, it is probable that total throughput of Ethiopia will grow but can vary significantly and is dependent on, amongst others, the political stability in Ethiopia. The current 8 percent grow per annum is feasible, but very high and should therefore not be directly planned for. The growing demand can be handled by MDP, but equally well by other dry ports in the country.

An interesting development that effects the logistics network in Ethiopia is the possible withdrawal of the most polluting vehicles in Addis Ababa. Alternatively, cargo will be distributed throughout the city using smaller, electric or otherwise less polluting vehicles. This measure is necessary because of the congested state of the city, and the poor air quality. It would however entail a changing logistics network as MDP is relatively far from the capital (80km) to transport goods in smaller vehicles. Additional transfer to a smaller vehicle around the city is time and cost consuming and therefore unlikely to be viable. In contrast, dry ports that are currently located around the city centre can handle import containers directly, as they are already connected to Djibouti port by rail. This measure seems sustainable, as cargo will be transported by rail over a longer distance, and less polluting trucks will be used for last mile transportation in Addis Ababa.

It will have major implications for MDP, as their current business model entails import containers only. However, because additional dry ports are still small, there is room to attract alternative cargo such as export containers and bulk. MDP has a convenient location for export products from South and West Ethiopia, as it does for dry bulk. These latter products can be handled and processed in Modjo Dry Port before being transported to its final destination.

For this study it is argued that the need for expansion of the container yard is dependable on future developments which will affect the entire network. The alternatives are therefore future proof only to a limited extent because of these uncertainties. However, demand is growing and improvements of MDP are highly necessary. A phased expansion of the dry port is the most viable direction, in which optimising the CY should have the highest priority because of the sustainable advantages of the measure. Alternative 3 could follow from alternative 1 when containers are handled more efficiently.

Stakeholder participation in sustainability study

The study is focussed around evaluating sustainability by including stakeholders explicitly in the analysis. In developed economies stakeholder participation and cooperation is increasingly adapted. In an African context the importance is more and more recognized. However, systematically analysing the input of stakeholders is challenging, and proved difficult in the current study: the response rate was low, the willingness to participate dependable on the stakeholder group and knowledge, and the quality of the input was debatable. This is a fragile part of the study, as it depends strongly on stakeholders' input.

Based on the outcome of this study, the interest of different stakeholder groups seems aligned, which simplifies implementation when indeed true. However, this finding could also be due to

the small and not representable stakeholder group that participated in the study. The possible impact is that the interests of some stakeholder groups are not well enough heard. For example, if more importers and exporters participated in the study maximising VAS is expected to receive a higher weight because of the value for these parties. Difference in interest between governmental and private parties are then expected to show, increasing the value of the analysis.

For MDP, it was expected that stakeholders would be very willing to participate in the study as it gives them a voice against the large governmental cooperation's. However, stakeholders were to a lesser extent used to think about sustainability than expected. It additionally proved difficult for stakeholder to weight the criteria. The stakeholders did not seem to enjoy the questions and rather stopped. When stakeholders were contacted, they indicated that they rather do not participate e.g. Meat producer: *"I appreciate your study but since I don't have much information and exposure about Dry port activities, I regret to inform you that I cannot answer your questions"*[5]. The lesson learned here is that stakeholder participation requires time, continuous effort and back up by an important stakeholder, such as the DMU or the WB. Considering the latter, their role is primarily on provision of the finances and doing a systematic stakeholder analysis was also new for the WB in Ethiopia. When the value of the framework is acknowledged by the World Bank, they can play a more active role in evaluating project alternatives on sustainability. Their position is unique as they can promote a sustainable stakeholder inclusive approach using the developed evaluation framework. The result could be improved by incorporating a large sample size, and doing the assessment backed with data. The outcome of the evaluation can be ultimately be used by the DMU to steer their choices. The cooperation of the DMU and other influential actors is therefore a major enabler for the value of the analysis.

Future studies. Considering this thesis, collaboration between the researcher and the DMU was difficult because a shared objective was lacking. It was challenging to convey the value of including stakeholders in achieving sustainability and shared responsibility to dominantly unilateral partners. Without their backup it proved difficult to contact the intendent stakeholders. The language barrier was especially a problem for community and internal stakeholder and posed a limitation on the possible stakeholders to include. For follow up studies it would be valuable to work together with a student of AAiT.

Personal development. For 2,5 months the researcher worked from the World Bank office in Ethiopia to conduct field research. When arriving in Addis Ababa, the future alternatives for MDP where not yet defined. Getting grip on the alternatives, what implications for the network are, and how this should be evaluated took a considerate amount of time. When the alternatives for MDP expansion where defined the research proceeded faster. However, this led to a slower collection of data. The largest improvement personally is requesting help when in Ethiopia. Input was only limited available by the WB and the EMAA which made it difficult to get in contact with the stakeholders. Dr. Teklu's help proved very valuable and the study would have been better if his input was asked for earlier.

[5] Email as response to ranking the alternatives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6 Conclusion

This study investigated the role of stakeholder's interest for developing sustainable expansion alternatives for Modjo Dry Port. The following research question was formulated:

How to evaluate strategic alternatives for sustainable expansion of Modjo Dry Port?

The sustainability of alternatives for MDP can be evaluated by ranking the different alternatives according to a set of carefully selected criteria. These criteria are grouped into social, environmental and economic criteria, all equally important to achieve sustainable development. Sustainability is improved by incorporating stakeholders in the analysis to ensure their involvement in the project, and to identify the main challenges. By systematically analysing the interest of the stakeholders using weights for the criteria, the most sustainable expansion direction is determined. For Modjo Dry Port focus should be on improving the current operations.

To come to this conclusion, the secondary research questions have been subsequently addressed.

1. What is a suitable framework to evaluate dry port expansion by different stakeholders in East-Africa?

The focus of the project is on sustainable evaluation of the alternatives. Sustainable development is comprised of social, environmental and economic sustainability. Sustainable development as applied in port development is not, but can equally be applied to dry port development with several slight adaptations. Especially environmental criteria are different because there is no marine environment in need of protection from being destroyed.

Until now, a standard gross list of evaluation criteria for sustainable development of ports, and especially dry ports, was not available. The gross list used in this research was compiled on the basis of extensive literature research and is presented as being comprehensive. It is presented as the basis for an evaluation framework which can and should be adapted to each specific project. As the basis of this framework is sustainable development, the criteria in the list are categorised according to the three pillars of sustainable development: social, environmental, and economic sustainability. For MDP specifically, four or five criteria from each category were selected which proved sufficient. With the development of this framework the first identified literature gap is addressed.

2. What are suitable design alternatives of Modjo Dry Port, based on the current situation?

Development of alternatives is a cyclic process. In the first iteration, the number of issues identified for development should be limited, and general in nature. On the basis of conclusions of the first iteration, subsequent cycles should narrow down and specify the issues. For MDP specifically, in the first cycle, expansion of size and improvement in operation efficiency are identified as the main issues for alternative development.

- What scenarios for cargo flows in Ethiopia, and specifically the flows through Modjo Dry Port, can be expected?

The size of future demand of MDP is uncertain and dependable on many different factors. Different scenarios for future demand have been constructed where throughput stays stable (base case) or total throughput grows with a factor four until 2030 (high case). Because of these large uncertainties it seems unwise to invest majorly in new, unfamiliar cargo segments.

3. How can the interest of different stakeholder be aggregated to develop the most suitable design?

It has been extensively shown in previous research that incorporating stakeholders gives them a sense of ownership in the project and makes the project more sustainable in the long run. The MAMCA is a tool that capitalises on this fact by requiring stakeholder input at several moments during the research. At the same time, it also provides useful insight into which possible alternative stakeholders prefer. By using the evaluation framework as provided, stakeholder preferences concern the sustainability of alternatives. For MDP specifically, different stakeholder groups showed similar interests, and the preference for different alternatives is equal amongst the groups. Weights of the stakeholder groups towards the final aggregated result can be varied depending on the aim of the project.

Applying the MAMCA proved more challenging than anticipated. Stakeholder response was lower than expected, partially due to cultural differences, partially due to the exploratory phase of the project. However, the MAMCA remains a promising tool for structurally incorporating stakeholder preferences, something for which a large demand remains in Ethiopia. By applying the MAMCA methodology in a developing country, the second research gap is addressed.

4. How do the alternative strategic designs perform for different stakeholder groups?

Analysis shows that the alternatives improving operation efficiency score markedly higher on sustainability. Without disregarding the necessity for growth in size, the main focus in developing sustainable alternatives should be operation efficiency. This finding contradicts with the overall tendency that diversification of cargo should be the highest priority. For the study to have impact, this result should be considered by the EMAA and WB for the further stages of the project at Modjo Dry Port.

6.1 Recommendations & future studies

In the final section recommendations for management and research are done.

For research. In a number of ways this study can be improved or expanded upon by further research.

To start with, quantitative measures should be incorporated when evaluating the alternatives according to the evaluation framework. This will increase the objectivity of the evaluation process and thereby improve the accuracy of the final result. This can be done by data collection from local sources, or doing estimations based on the characteristics of the defined alternatives. The cost (positive and negative) of the different alternatives should be taken into account.

In addition, the future demand of MDP should be considered in larger detail to underpin the relevance of the different alternatives. For the current exploratory study, the developed scenarios suffice, but there are large uncertainties considering future demand. MDP will benefit majorly from addressing these more accurately. It will be interesting to understand in more detail how the policy changes will affect demand for MDP and how the dry port can be ahead of these developments.

Moreover, the evaluation framework was determined by verification of a small set of stakeholders and literature. As a separate study the framework can be improved by considering a larger set of stakeholders for the verification of the criteria. It would be interesting to research whether it is more suitable to let stakeholder groups define their own criteria for weighing instead of predefined ones. Workshops and meetings are necessary to increase awareness amongst the stakeholders of the effects of an expansion project. Also, it is useful to challenge the application of the framework in a slightly different context or in a different country for its suitability.

Finally, the relation with the DMU/point of contact is important for performing a similar study successfully. Being considerate about the importance of this relation for the contact with the additional stakeholders will ease the study. Sustainable expansion considering a large set of stakeholders is new in an Ethiopian context and patience and determination for the project are required.

For management. In a number of ways, the study is relevant for the management of the expansion project. To start with, the study provides a hands-on tool that can be used to systematically integrate stakeholders for the evaluation sustainable expansion. When the alternatives are in a more defined state, this framework helps to evaluate them considering sustainability, which they promote. Even without incorporating stakeholders, the framework can be used by the management to evaluate the sustainability of the alternatives themselves.

In addition, the study identifies four main stakeholder groups: community and internal stakeholders are added to the existing list of the DMU. These groups should be taken into consideration throughout the project because of their proven importance in comparable port projects.

Moreover, the future demand of MDP should be critically discussed and cooperation with dry ports around Addis Ababa should be sought. If indeed changes in the legal framework for cargo transportation in the capital are made, it is advised that MDP considers these developments progressively. Country wide demand will be large enough to accommodate different cargo without hindering this sustainable development.

Also important on a more practical note: standardisation of measurement units should be done to increase convenience of comparing the dry port's (sustainable) performance to other sites. For example, the capacity of the terminal should be expressed in maximum throughput per year instead of showing the ground slot capacity.

Finally, the outcome of this study can be directly used by management by considering improvement of the current terminal. The analysis shows that improvement of operations is a sustainable direction for development, both considering the evaluation criteria, and considering the expected future demand and flexibility to adapt.

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Appendices

A. Role of Ethiopian government in cargo logistics

The Unimodal and Multimodal Systems

There are two forms of transport along the Ethio-Djibouti corridor, namely unimodal transport and multimodal transport (MMT). The terminologies are used in the context of contract of carriage expressed through the bill of lading and not the actual modes of transport. MMT refers to the shipment carried under an MMT bill of lading (BoL) issued by an accredited Multimodal Transport Operator, the governmental operated shipping line (ESLSE), which assumes the liability for the shipment. In contrast, 'unimodal' refers to the shipment carried under separate contracts of carriage performed by different carriers on different segments of the transport journey. This entails segmented BoLs, one for ocean carriage and another for land transport. Liability for the cargo is transferred from one carrier to the next after each segment of the journey is completed. In practice, the multimodal system is used solely for the import of containerized cargo and cars and requires shipments to be cleared at the dry ports in Ethiopia (mostly MDP). To a large extent, the use of the multimodal system has contributed to faster removal of goods from the Port of Djibouti, alleviating congestion in the container terminal. The MMT BoL makes it possible to pass through Djibouti under customs seal and transit without the need for customs clearance. The unimodal system is used for other imports, mainly bulk and breakbulk, and the export of all types of cargo. Imported goods are cleared by customs in Djibouti. Most importers of containers use the multimodal system because this offers the advantages of lower storage charges and deferment of payment of duties.

Critical note: for smaller importers it is not possible to import their goods via the unimodal system and are thus required to use the facilities of the ESLSE. Even though the system should be efficient because import is done under one BoL, importers prefer the unimodal systems as cost are competitive. Cargo is now cleared in one of the dry ports constructed by the government where

Logistics Services Providers

Logistics services in Ethiopia are dominated by ESLSE, a government-owned enterprise. ESLSE provides shipping services, arranges the transfer of goods between Djibouti and Ethiopia, and operates MDP. Current government policy means that ESLSE is the only provider of multimodal services. Truck operations are provided largely by the private sector, and ESLSE contracts trucking services between the port and Modjo.

B. United Nations Sustainable development goals

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all (UN, 2018). Contribution of port development to the sustainable development goals is emphasized by (GreenPort, 2017). The exact role of ports towards the SDGs is not yet fully defined. The port sector is not represented by a single SDG, but can be found in across several of the 17 SDGs. Ports have, at least, the following role:

- Contribute to societal development through job and wealth creation
- Ports are (usually) located at ecologically valuable areas where local community and environment should not be brought harm
- Sustainability requirements for transport are increasing which requires ports to contribute to sustainability as well

The presence of the SDGs in the selected criteria is shown in the text to highlight the impact and relevance of the expansion. After selecting the criteria for evaluation of the specific project, a number of SDGs are not included in the analysis anymore.

C. Methodology for demand forecasting Modjo Dry Port

Time-series models are based on historic data which is not applicable in the case of MDP as they were established only recently (in 2009). In this period, the growth in capacity went hand-in-hand with growth in volume, which was not linear with the total throughput of Ethiopia. Additionally, cargo types at MDP are limited to imported containers, where future demand includes other types as well.

Cause-and-effect models assume that the variable to be forecasted is exhibited by the explanatory relationship with one or more independent variables. The idea is to identify the relationship between variable and throughput to forecast future demand. For MDP this is a suitable measure as container growth is usually related to GDP growth. Two main objections for using this method are:

1. Container throughput in MDP does not relate with country wide throughput;
2. The correlation between bulk throughput and GDP is less obvious.

It is therefore necessary to complement the quantitative data with qualitative observations.

Judgmental or qualitative models. These are estimating models that drive on expert opinions instead of measurable and verifiable data. Because of the objections mentioned earlier, this method is suitable to complement GDP regression. Qualitative data sampling consists of three main methods: interviews, observations and written documents which are all used in the current study. Written documentation reviewed was derived from the EMAA, the WB and consultancy firms working on the ETLP. Observations on current throughput and train operations is used to substantiate the information on the current situation from documents. The interviews with stakeholders where used as input to estimate future market share of different cargo types (containers, dry bulk, etc.).

D. Survey among stakeholders to validate evaluation criteria

Introduction text:

Dear participant,

As part of my master thesis at Delft University of Technology in the Netherlands I am studying the operations at Modjo Dry Port, and the future expansion. I am studying civil engineering focust on transportation planning and logistics.

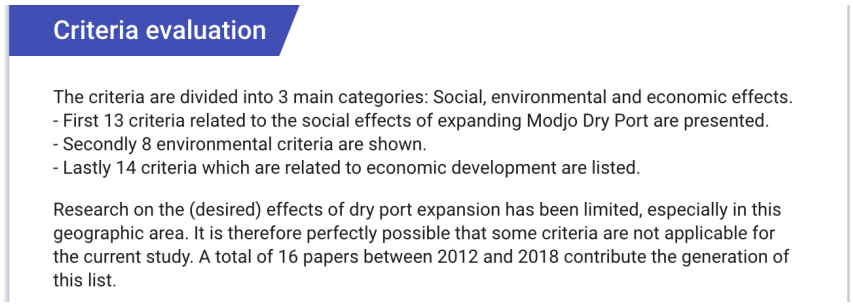
The main aim of my study is developing a framework to evaluate port performance that takes different stakeholder groups in account.

In this survey your input on evaluation criteria for the design of Modjo Dry Port is asked. For all criteria the question simply is: do you think this criteria is important for the development and expansion of Modjo Dry Port.

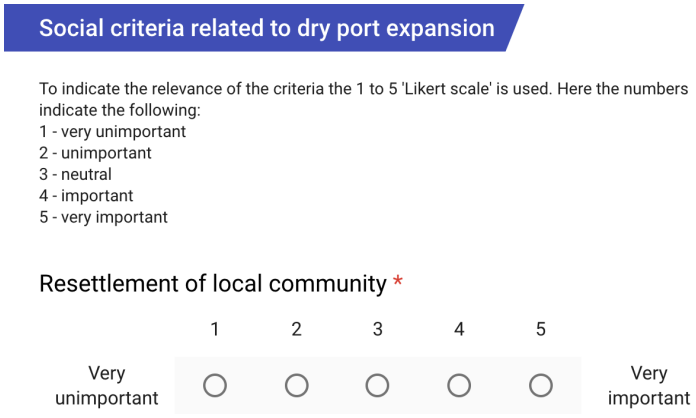
In literature, such a framework for dry port development does currently not exist and your input is therefore highly valued. A total of 35 criteria are selected from a wide range of studies which will be deduced to 9 - 12 criteria specific for Modjo Dry Port based on your input.

Confidentiality: the results will be treated confidentially and responses will not be linked back to you or your company. If you do not feel comfortable to give your company name, this is not required. It is important to know whether you are working at the port area, are part of the local community, are a private or public company (or other).

Thank you!



Explaining the aim of the study



Example of question

E. Stakeholder and expert input to rank the alternatives

Text in email:

Dear stakeholder of Modjo Dry Port,

For my master thesis I am building a framework to evaluate dry port expansion in Modjo. The study is part of the Master program Civil Engineering a**t Delft University of Technology in the Netherlands**, supported by the World Bank in Ethiopia and Addis Ababa Institute of Technology. I stayed in Ethiopia for three months to collect data and conduct interviews. The aim of the study is to evaluate three different alternatives for the expansion design of Modjo Dry Port. Using a Multi Criteria Analysis (MCA), I want fulfil this aim.

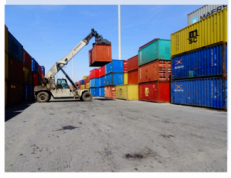
Please feel free to contact me with questions when it is not clear. Looking very much forward to receiving your input, and thank you in advance!

Text in Excel:

Dear stakeholder of Modjo Dry Port,

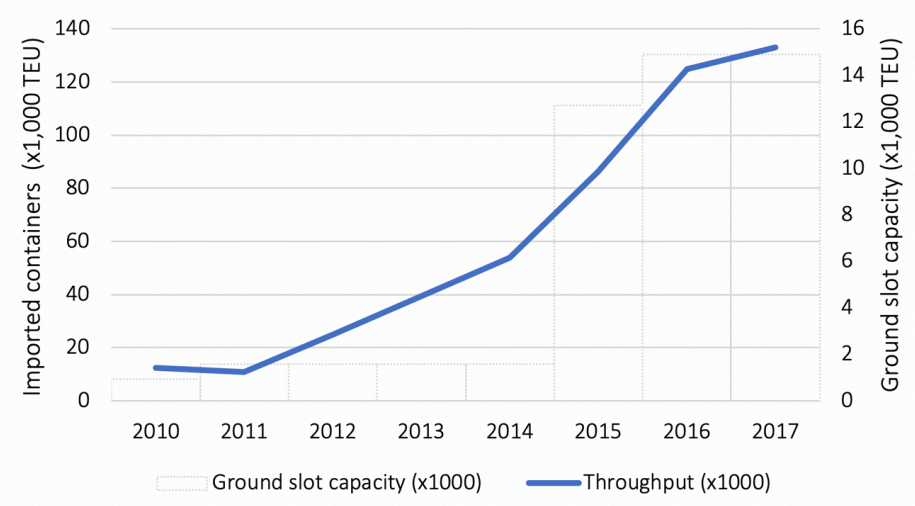
- As part of my master thesis at Delft University of Technology I am conducting research about the expansion of Modjo Dry Port in Ethiopia
- For three months I stayed in Addis Ababa at the World Bank to gather data and conduct interviews
- The aim of the study is to evaluate three different alternatives for the expansion design of Modjo Dry Port
- The alternatives are presented in the following tab, and you are asked to give your opinion on 12 evaluation criteria
- The current operations at the Dry Port are shown first
- Additional context is provided below
- It will take approximately 15 minutes of your time
- Your input is highly appreciated!

Current operations at Modjo Dry Port

Cargo	Equipment	Automation	Value added services	Capacity
Only container import and transport of empties	5 reach stackers 1 gantry crane (which not in use)	No automation, container yard stacking is manually organized	Currently not offered at Modjo Dry Port	The capacity of Modjo Dry Port lies around 300,000 TEU
				
Railway station	**Infrastructure**	**Safety**	**Warehousing**	**Employees**
Currently 4 tracks of 220m, train is split in four parts before unloading	Multiple wholes in the terminal, parts are unpaved, generating dust when windy	Multiple accidents per year No zones for pedestrians No helmets nor fluo jackets	No stacking equipment Only for customs, not storage	Permanent labour: 589 Daily labour ((un)loading of containers): 576
				

Imported containers Modjo Dry Port

Container throughput in Modjo Dry Port grew significantly over the last years
Note: slot capacity grew as well



You may now proceed to the following tab

Dear stakeholder of Modjo Dry Port,

- After reading the introduction tab, you may now proceed with the evaluation of the alternatives
- The evaluation matrix is shown below
- For all evaluation criteria, the different alternatives must be rated according to the current situation - which is neutral
- For each criterion, the alternative can perform: negative, slightly negative, neutral, slightly positive and positive in comparison to the current situation
- The characteristics of each alternative are explained first, in yellow, green and orange respectively
- Your input will help to determine the best alternative for Modjo Dry Port

	Size: Low Operations: Low	Size: Low Operations: High	Size: High Operations: Low	Size: High Operations: High
				
	Alternative 0; current situation	Alternative 1; improved operations	Alternative 2; similar operations, increased size	Alternative 3; improved operations, increases size
Cargo Type	Containers (import)	Containers (import & export)	All (containers, dry bulk, RoRo)	All (containers, dry bulk, RoRo)
Equipment	Reach stackers	Reach stackers	Reach stackers	Reach stackers + Gantry cranes
Automation	a = No	> a Container yard, scanning devises	a	>> a All systems automated
Value added services	No	Yes	Some	Yes
Extending length of railway station	No	No, but handling of containers is improved	Yes	Yes
Improving infrastructure	No	Yes	No	Yes
Safety	sf = Low (multiple deadly accidents per year)	>> sf	~ sf	> sf
Capacity (containers)	c = ~300,000 TEU	>>> c (TEU) ~1,000,000 TEU	c (~300,000 TEU) (possibility to expand further)	>>> c (~1,000,000 TEU) (possibility to expand further)
Capacity (e.g. bulk)	0	0		
Average dwell time	t = ~60 days	<< t	T	<< t
Warehousing	2 warehouses (no storage/racks)	Racks for customs and storage	Only for customs (no racks)	Racks for customs and storage
Employees (with similar demand)	e = ~1,100	<< e	e (possibility to grow significantly when bulk is added)	< e (possibility to grow to e when bulk is added)
Size	s = 25 ha (CY= container yard)	s	s, possibility to expand ~100 ha for bulk terminal	s, possibility to expand ~100 ha for bulk terminal

Evaluation matrix

Alternative scores:
Negative
Slightly negative
Neutral
Slighly positive
Positive

Evaluation criteria For all of the alternatives you are asked to rank them according to a number of carefully selected evaluation criteria for dry port expansion
The evaluation criteria are in the first row of the matrix

		Social					Environmental				Economic				
	Evaluation criteria	Employment	Stakeholder consultation	Safety	Resettlement of local community	Dust	Minimising emissions	Waste management	Noise pollution	Protection of land and natural environment	Productivity	Transport cost & time	Maximizing VAS	Reliability of service	Accessibility of railway
		Number of relevant jobs created	Including stakeholders in the process of dry port expansion.	Safety for employees & community	Impact of expansion on relocating local community	Dust generation due to wind and operations at Modjo Dry Port	Minimizing emissions from port operations, transport and industries	Reuse and recycle rate; treatment of hazardous waste	Minimizing noise pollution	Ecological environment protection in port area	Storage Area productivity, crane utilization, vehicle utilization	Reduction of transportation cost and time	Value added activities in port area	For customers of the port	Corridor capacity and capacity at the terminal
0	Current situation	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
1	Improved operations														
2	Similar operations, increased size														
3	Imporved operations, increased size														

Input required for:
Alternative 1
Alternative 2
Alternative 3

F. Potential benefits of dry port for different stakeholders

Source: (FDT, 2007; Monios & Wilmsmeier, 2012; Rodrigue & Notteboom, 2009; Roso et al., 2009; UNESCAP, 2017; Wu & Haasis, 2018)

Type	Stakeholder	Advantage
Economic & business	All	Reduced transport cost of moving freight inland by rail rather than road
	All	Reduced transport costs reflected in lower prices for traded goods
	Government	Lower prices for traded goods providing stimulus for trade and GDP growth
	Government	Investment in facilities is likely to generate other economic activities in the vicinity (Dry Ports can grow into SEZs)
	For port authorities	More efficient operation (less congested quay-side)
		Greater expansion opportunities / expanded hinterland
		Increased capacity
		Greater integration of transport into the supply chain
		Improved access to seaports
		Cheaper logistics
	For industry	Reduced transport cost of moving freight inland by rail rather than road
		More efficient access to services (Customs)
		Access to additional logistics services (packaging, labelling, warehousing)
	For road operators	Less time in congested roads and terminals (greater asset utilization)
		Reduced cost of road maintenance (through fewer trucks)
		Reducing the use of expensive located areas
	For rail operator	Economies of scale
		Gain market share – high rail network utilisation
	For shippers	Green marketing
		Improved sea port access
	For port cities	Less road congestion
		Better land use opportunities
Social & environmental	For society	Reduced GHG through modal shift
		Reduced number of road accidents through fewer trucks on highways
		Reduced congestion on road network
	For people in hinterland areas	Enhanced employment opportunities
		Reducing environmental problems in large cities

G. Ethiopian trade

Ethiopian International trade			
Import $15.87 billion (2015)		Export $3.16 billion (2015)	
Main products	Main partners (share)	Main products	Main partners (share)
Machinery and aircraft	China (20.4%)	Coffee	Switzerland (14.3%)
Metal and metal products	United States (9.2%)	Gat	China (11.7%)
Electrical materials	Saudi Arabia (6.5%)	Gold	United States (9.5%)
Petroleum products	India (4.5%)	Leather	Netherlands (8.8%)
Motor vehicles	Belarus (1.8%)	Live animals	Saudi Arabia (5.9%)
Chemicals and fertilizers		Oilseeds	Germany (5.7%)

H. Stakeholder participation

		Stakeholders involved	Company/role	Note on contact
Market players	1	Shipping companies	Ethiopian Freight Forwarders & Shipping Agents Association	(1), (2)
	2	Logistics/inland transport operators	Panafric global	(1)
	3	Logistics/inland transport operators	Champion Shipping PLC	(1)
	4	Governmental[6]	Ethiopian Railway Cooperation	(1), (2)2x
	5	Governmental	Transport Programs Management Office	(1), (2), (4)
	6	Logistics/inland transport operators	Ethiopian Horticulture Producers Association	NR
	7	Logistics/inland transport operators	MACCFA	(1)
	8	Logistics/inland transport operators	Ethiopian coffee exporters Association	NR
	9	Shipping companies	MAERSK Shipping Agent	(1)
	10	Logistics/inland transport operators	Industrial parks Hawassa	NR
	11	Logistics/inland transport operators	Meat producers	NR
	12	Flying swan project	Mercator Novus B.V.	NR
Public policy makers	13	Port Authority	ESLSE	(1), (3)
	14	Port Authority	EMAA	(1), NR
	15	Environmental department	Ministry of Environment, Forest & Climate Change, Ethiopia	No contact details
	16	Bank	World Bank	(1), (2)2x, (4)
Community	17	NGO	e.g. World Food Programme	(1), (3)
	18	Environmental groups	e.g. Paper recycling	(1)
	19	Residents	Hotel owners	(2), (3)2x
	20	Residents	Municipality Modjo	(1), CB
	21	Residents	Citizens	CB
	22	University	Addis Ababa Institute of Technology	(1)
	23	Press	Multiple	Not contacted
Internal stakeholders	24	Employees	Clearance chief	(1)
	25	Employees	Engineering chief	(1), (3)
	26	Employees	Yard planner	(1)
	27	Employees	HRM manager	(1), (2), (3)
	28	Employees	Operational manager	(1), (2)
	29	Employees	Customs manager	(1)
	30	Employees	Safety manager	(1), (3)
	31	Employees	Reach stacker operator	CB
	32	Employees	Office employee	CB
	33	Employees	Warehouse staff	CB

(1) = Interviews for the analysis of the system
(2) = Validation of criteria evaluation framework
(3) = Weights
NR = no response on calls and/or emails
CB = cultural barrier, mostly language

[6] These governmental institutions act as private companies, and have no say in the development of MDP

I. References for evaluation criteria

	Environmental								Social														Economic															
	1 Minimizing GHG	2 Waste (recycling and hazardous goods)	3 Minimizing energy (type of source)	4 Protection of land and natural environment	5 Noise pollution	6 Soil pollution due to activities of the dry port	7 Light pollution due to 24h operations	8 Existence of environmental programme	9 Replacement of local community	10 Employment generation	11 Education for local community	12 Institutional, legal and political impact	13 Heritage and cultural impact	14 Visual intrusion	15 working environment	16 Quality of living	17 Safety: Traffic	18 Safety: diseases	19 Safety: employees	20 Economic equality	21 Stakeholder consultation	22 Gender equality	23 Maximizing value added services	24 Range of value-added services	25 GDP generation (local and country)	26 Income and profit port	27 Productivity port area	28 Throughput port	29 Congestion	30 Transport cost & time	31 Investment cost and generation	32 Accessibility of multimodality	33 Reliability of service	34 Customs clearing efficiency	35 Cargo safety in port	36 Employment [also economic]	37 ICT	38 Market share %
(Di Vaio et al., 2018)	v	v	v																																			
(Jansen et al., 2018)	v						v		v	v																												
(Xiao & Siu Lee Lam, 2017)	v	v							v	v		v	v		v	v							v		v	v	v											
(Merk & Dang, 2013)	v									v													v					v										
(Schipper et al., 2017)	v		v	v						v	v					v											v	v	v	v								
(Lam & Van De Voorde, 2012)	v		v	v																																		
(EMAA, 2016)	v	v	v	v	v	v			v				v		v		v	v	v						v													
(Nguyen & Notteboom, 2016)	v				v					v				v			v						v	v						v	v	v						
(Prause & Schröder, 2015)	v	v	v								v						v		v									v		v		v	v			v		
(Del Saz-Salazar & García-Menéndez, 2015)	v				v				v					v																								

	Environmental							
	1 Minimizing GHG	2 Waste (recycling and hazardous goods)	3 Minimizing energy (type of source)	4 Protection of land and natural environment	5 Noise pollution	6 Soil pollution due to activities of the dry port	7 Light pollution due to 24h operations	8 Existence of environmental programme
(Vellinga et al., 2017)	v							
(Gohomene et al., 2016)								
(Denktas-Sakar & Karatas-Cetin, 2012)	v	v	v	v				
(Oosterwegel, 2018)				v				
(Lu, Shang, & Lin, 2016)	v	v	v	v	v		v	v
(Feng et al., 2008)								
(Amber Coast Logistics, 2013)								v
(Federal Democratic Republic of Ethiopia, 2015)	v							
(Rezaei et al., 2018)								

	Social													
	9 Replacement of local community	10 Employment generation	11 Education for local community	12 Institutional, legal and political impact	13 Heritage and cultural impact	14 Visual intrusion	15 working environment	16 Quality of living	17 Safety: Traffic	18 Safety: diseases	19 Safety: employees	20 Economic equality	21 Stakeholder consultation	22 Gender equality
(Vellinga et al., 2017)			v			v								
(Gohomene et al., 2016)			v											
(Denktas-Sakar & Karatas-Cetin, 2012)		v	v		v				v					
(Oosterwegel, 2018)	v	v										v		
(Lu, Shang, & Lin, 2016)		v			v	v		v	v	v	v	v	v	
(Feng et al., 2008)														
(Amber Coast Logistics, 2013)		v												
(Federal Democratic Republic of Ethiopia, 2015)														v
(Rezaei et al., 2018)														

	Economic															
	23 Maximizing value added services	24 Range of value-added services	25 GDP generation (local and country)	26 Income and profit port	27 Productivity port area	28 Throughput port	29 Congestion	30 Transport cost & time	31 Investment cost and generation	32 Accessibility of multimodality	33 Reliability of service	34 Customs clearing efficiency	35 Cargo safety in port	36 Employment [also economic]	37 ICT	38 Market share %
(Vellinga et al., 2017)	v											v				
(Gohomene et al., 2016)	v											v	v			
(Denktas-Sakar & Karatas-Cetin, 2012)	v			v				v	v							
(Oosterwegel, 2018)									v							
(Lu, Shang, & Lin, 2016)				v	v	v			v				v	v		
(Feng et al., 2008)		v			v			v		v	v		v	v	v	
(Amber Coast Logistics, 2013)	v			v	v	v	v	v	v	v		v	v		v	v
(Federal Democratic Republic of Ethiopia, 2015)																
(Rezaei et al., 2018)				v				v				v	v			