

TOWARDS A FRAMEWORK FOR INTEGRATED, ECOSYSTEM-BASED PORT DEVELOPMENT

by

P. Taneja¹, T. Vellinga¹, K. Appeaning Addo², J. Slinger¹, H. Vreugdenhil^{1,3}, W.P. de Boer^{1,3}, A. Kangeri⁴, B. Kothuis¹, M. Koetse⁵, L. Hagedoorn⁵, C. van Dorsser¹, E. Mahu², B. Amisigo²

ABSTRACT

This paper describes an integrated, ecosystem-based research project exploring what it means to be a sustainable port in a developing country context. Africa is one of the few areas in the world where greenfield port development is still occurring in addition to brownfield development. This means there are many challenges and opportunities to design for sustainability and to nudge existing ports towards more sustainable activities. A stepwise, case study oriented approach to tackling these issues is explicated in an effort to understand the advantages for port developers and their financiers to move in this direction.

1. INTRODUCTION

A paradigm shift is required in our approach to large scale infrastructure development including ports, whereby the emphasis lies on achieving our objectives in an ecosystem and societal context in an uncertain environment. There is a growing recognition of the need for more sustainable approaches to port development aimed at balancing social, environmental and economic aspects. In spite of this, an integrated inter-disciplinary approach to sustainable port development, which embraces the four perspectives of engineering, ecosystem services (ecology and economy) and governance is lacking. The ongoing NWO-WOTRO UDW project "Integrated and Sustainable Port Development in Ghana within an African context" (NWO, 2018) addresses this gap.

The project which started in May 2016 spans 3 years and is carried out by a multidisciplinary consortium, wherein academia, applied research institutes, knowledge institutes, practitioners and potential users collaborate as partners and interact with a broad range of local stakeholders. It adopts an inter-disciplinary approach that integrates different aspects of sustainable port development to create a knowledge base serving a design-framework and accompanying design tools that can be applied in developing more sustainable ports. Using a case study in Ghana as the central application focus, subsequent replication of new knowledge and practices is expected within Ghana and beyond, followed by eventual institutionalization through bottom-up adoption and activated Pan-African networks.

2. TOWARDS SUSTAINABLE PORTS IN AFRICA

The selected case study is the Port of Tema, located in the south eastern part of Ghana along the Gulf of Guinea. Tema has evolved from a small fishing village in the mid twentieth century to become Ghana's leading industrial centre and seaport in the last decade. The port is undergoing expansion to serve rising cargo traffic volumes as Ghana's economy maintains its high rate of growth. To integrate knowledge and learning on the case study, four sub-projects focussing on engineering (P1), ecology (P2), economy (P3) and governance (P4) have been defined.

¹ Delft University of Technology, Faculty of Civil Engineering & Geosciences, & Faculty of Technology, Policy & Management, Netherlands, j.h.slinger@tudelft.nl

² University of Ghana, Department of Marine and Fisheries Sciences, Ghana

³ Deltares, Netherlands

⁴ Wageningen Marine Research, Netherlands

⁵ Institute for Environmental Studies, Netherlands

P1 *Port engineering and design* views the port as a component within the coastal zone and develops alternative layouts for the port expansion of Tema. Hereby, the principle of Building/Working with Nature is gainfully applied in exploring infrastructural options to maintain, restore or offer opportunities to coastal ecosystems. The changes engendered by alternative port layouts and diverse port infrastructural designs are studied in terms of their ecological and societal effects.

P2 *Marine ecosystems and coastal erosion* examines the dynamic interactions between infrastructural elements and the coastal ecosystem. Here the emphasis lies not on the infrastructural elements, but on the ecological components, their functioning and evolution from the start of port development in Tema. Understanding of the changes in the functioning of the ecosystems are sought so that opportunities to create added value for nature from the the port can be identified. For instance, by countering erosion problems and integrating restoration of ecological habitats in new road infrastructure development.

P3 *Economic valuation of ecosystem services* applies state-of-the-art methods to quantify the evaluation of changes in ecosystem service delivery to humans. This allows the inclusion of ecosystem services in the socio-economic analysis of port development alternatives. Social aspects identified as relevant in P4 will also be valued.

P4 *Governance of green port development* formulates an opportunity-oriented implementation model for port development in which port authorities, contractors, nature conservation organizations, ecologists, engineers and local stakeholders cooperate to formulate a better fit between ports and their social-ecological landscape. In this process, the values that stakeholders hold regarding the future alternative states of the port-city and its surroundings are accessed.

The overall project encompasses the following steps:

- gathering relevant data for the pilot project through desk studies, field research and workshops;
- exploratory studies and brainstorm sessions to formulate alternative port layouts and identify potential ecosystem services;
- stakeholder-inclusive workshops to elicit stakeholder values and local knowledge;
- integration of the findings into alternative conceptual port layouts. These alternatives include: status quo as reference layout, the current port expansion plan of Ghana Ports and Harbours Authority (GPHA), an incremental port development plan with a focus on value addition by considering sustainability, and an innovative layout;
- detailed assessment of alternative port layouts with respect to functionality of port operations, morphological effects, environmental impacts on the marine and coastal ecosystems, and economic valuation of ecosystem services;
- a detailed assessment of stakeholder values in relation to port-city development and the effects on surrounding ecosystems;
- the formulation of a framework for sustainable port development, tested in Tema, Ghana.

The pilot case study will result in a port design for Tema that complies with the requirements as to functionality and sustainability. The knowledge and insights gained from the case study are also used to develop a potentially generic framework and tools for stakeholder-inclusive design of sustainable ports. Knowledge dissemination in accordance with a well-formulated research uptake strategy forms an important component of the project, as does the desire to test the developed framework by applying it on other ports in Africa and elsewhere.

3. CONCLUDING

By describing this on-going research project, including the underlying vision, the challenges and the objectives, the activities pertaining to the selected pilot project in Ghana, as well as the envisaged end results, this paper aims to share new knowledge and learning about the practice of port development. Finally, as the approach and underlying principles are applicable to large scale infrastructure development at other locations, we encourage others to apply these principles in the sustainable development of ports.

References

NWO (2018). Integrated and Sustainable Port Development in Ghana within an African context, Urbanising Deltas of the World Program, URL: <http://www.nwo.nl/en/research-and-results/research-projects/i/95/13995.html> ; accessed February, 2018.

Acknowledgements

The authors wish to express deep appreciation to the Netherlands Organisation for Scientific Research (NWO-WOTRO) for financing this research project (nr. W07.69.206) under the Urbanizing Deltas of the World programme.

DESIGNING FOR STAKEHOLDER VALUES IN PORT DEVELOPMENT IN AFRICA

by

J. Slinger¹, P. Taneja¹, B. Kothuis¹, H. Vreugdenhil^{1,2}, W.P. de Boer^{1,2}, A. Kangeri³, M. Koetse⁴, L. Hagedoorn⁴, C. van Dorsser¹, E. Mahu⁵, B. Amisigo⁵, K. Appeaning Addo⁵, T. Vellinga¹

ABSTRACT

This paper addresses the need for stakeholder-inclusive design in sustainable port development. This involves learning about the values and knowledge resources of local stakeholders at an early stage, but is a step that is often omitted in current port planning processes. However, it is essential in creating added value and in avoiding costly delays when port development is stopped or delayed by social impact findings at a later stage. A stakeholder engagement process for the Port of Tema, Ghana, is used to illustrate the types of activities required and offer insights in the outcomes. In particular, a game structuring method applied in a 50-people workshop in February 2017 demonstrated that the expertise of local stakeholders and insight into their preferences regarding potential futures for the port city and its surroundings can inform planners, port authorities and engineering scientists about what it means to be a sustainable port in a developing country context.

1. INTRODUCTION

Sustainable development recognizes that growth must be both socially inclusive and environmentally sound to meet the needs of present and future generations. While seaports provide an essential link to the world market, enabling countries to trade their goods and strengthen their economy, these global and regional benefits do not always translate into benefits to local stakeholders. Indeed, there is often a mismatch between the positive global and regional effects of port development and the impacts (dis-benefits) that can be experienced locally (Rodrigue, Comtois and Slack, 2017; Merk, 2013). Port development requires a paradigm shift from a traditional approach to a stakeholder-inclusive, integrated approach to be sustainable (Vellinga et al., 2017; Schipper et al., 2017).

The Ghanaian Port of Tema forms the focus point for an ongoing project “Integrated and Sustainable Port Development in Ghana in an African Context” (NWO 2018). The research project is carried out by a consortium comprising the University of Ghana, and Dutch knowledge institutes and private sector companies. While the broad research aims are to gain insights in how to develop integrated and sustainable African ports that meet economic, social and environmental demands, one of the specific objectives is to find out what local stakeholders value as a sustainable port, in that it (i) creates value for stakeholders working and living in the immediate environment of the port, (ii) can still meet demands in 50 years, and (iii) can grow apace with economic developments of the future. The purpose of this paper is to provide tangible examples of the range of stakeholder-inclusive, value-based interactions implemented in the port city of Tema.

2. THE STAKEHOLDER ENGAGEMENT PROCESS

Recognising that stakeholder-engagement is a prerequisite for sustainability, four activities were initiated. The first activity involved organising a stakeholder workshop prior to the inception of the project. This occurred in Tema in 2015, and the outcomes were used to refine the focus of the research project and ensure that it addressed issues raised by the workshop participants. The

¹ Delft University of Technology, Faculty of Civil Engineering & Geosciences, & Faculty of Technology, Policy & Management, Netherlands, j.h.slinger@tudelft.nl

² Deltares, Netherlands

³ Wageningen Marine Research, Netherlands

⁴ Institute for Environmental Studies, Netherlands

⁵ University of Ghana, Department of Marine and Fisheries Sciences, Ghana

participants included local, regional and national authorities, industry, port developers, tourism and nature interest groups, amongst others. Participants first played the serious game Port of the Future. This is an interactive game in which players assume the roles of various stakeholders and decide on measures to be implemented during the process of port development. Each round in the game involves a negotiation within and between the different roles. The envisaged learning relates to the potential sustainability of measures and the importance of negotiating agreements on measures. The game served as a communication tool to bring across the significance and implications of sustainable port development for stakeholders, and helped to deepen understanding of different and often conflicting interests while attempting to create a port that not only serves economic functions but is in harmony with the surrounding ecosystems. Following the game, participants were encouraged to elaborate and discuss the issues they considered of relevance for Tema. The outcomes were an increased awareness of sustainable port development, and concurrence amongst the participants on the economic, ecological and social aspects that the project should address. These outcomes were included in the “Integrated and Sustainable Port Development in Ghana in an African Context” project proposal (NWO 2018).

Next, a workshop for project partners and supporting parties (see Vellinga (2017) for information about the project organization) was held in Delft, the Netherlands, in September 2016 with similar objectives (Vreugdenhil, 2016). The Ghanaian researchers participated in the workshop through an active skype link. The workshop agenda incorporated an introductory presentation on the project, which included the input from the first workshop, a question and answer session, a personal mini-survey over what is (or is not) a sustainable port in Tema or an ideal world. This was then followed by group sessions on sustainable ports and general discussion. Then, the serious game Port of the Future was played as part of the workshop. This was done for parity with the stakeholder workshop in Ghana. Finally participants were asked to reflect on workshop. The outcomes were similar to the first workshop in Tema, namely increased awareness of sustainability and consensus on the most important issues to address via the project. In addition, the connectedness of the network around the project was strengthened, and the inputs and insights from the Ghanaian partners added depth to the discussion on sustainability within an African context.

Following an intensive six-month period of data accumulation and research, a multi-stakeholder workshop was organized at the Ghana Ports and Harbours Authority Headquarters (GPHA Tower) in Tema in February 2017. This crucial activity in the overarching research project was designed to engage local port-related stakeholders in an innovative, value-based exploration of the future of Tema and its port. Clearly, the selection of participants and the method employed to engage with stakeholders are critical to success here. Invitations to stakeholders were issued on the basis of their involvement with the port. So, participants were drawn from different layers within the GPHA, and ranged from freight forwarders, local businesses involved with the port, port developers, to interest group representatives for tourism and the coastal ecosystem, as well as local scientists. More than 50 people attended the workshop, participating thoughtfully and enthusiastically in the different steps in the process. A six step game-structuring methodology (see Box 1) underpinned the workshop (Cunningham et al. 2014; Slinger et al. 2014).

The multi-stakeholder workshop was grounded in a wider stakeholder-inclusive situation assessment. Because the multi-stakeholder workshop was oriented to port-related stakeholders, an additional process of interviewing local residents with no direct relationship to the port was initiated in February 2017. This process was continued in 2018, resulting in more than 25 interviews shedding light on the effects of port development on those who live in, or near, Tema. These include traditional leaders, the original inhabitants of Tema prior to Port construction, local fishermen, teachers, immigrants to the area, long-time residents, town-planners and many more. The effects on these stakeholders are both positive and negative and vary in their impact on the lives of the people concerned. The envisaged output of this process is a deep understanding of the long term consequences of port expansion in all its facets, captured in a book that is currently under preparation.

Game structuring is a transdisciplinary practice developed specifically for environments in which multiple stakeholders, holding diverse values, are involved in the long term management of a social-environmental system, such as Tema and its Port. The purpose is thus not to reach consensus nor to solve conflicts, but rather to explore the existing different interests, values, potential and preferred futures, as well as the potential clusters of actions belonging to these futures and the associated restrictions, objections and hurdles. The workshop method rests on operations research traditions, using game theory in combination with techniques such as systems modeling and community narrative generation in particular. This potentially offers the participants in such a long term social-environmental negotiation a wider view on their own and others' positions, both now and in the future. The aspiration is that this leads to commitments to joint action based on shared values on the part of participants.

Workshops based on the game structuring approach have been conducted in South Africa (Slinger et al., 2014), the Houston Galveston Bay Area (Cunningham et al. 2015), and the island of Texel in the Netherlands. In all these cases, the method was experienced positively by participants and has been associated with increased stakeholder engagement in local decision making processes in the subsequent months

The game structuring, value-based design method as applied in Tema, Ghana entailed six steps:

1. Getting acquainted
2. Developing the system story; local stakeholders on past, present and future of Tema and its Port
3. Developing the system story; researchers on Sustainable Ports in Africa, Tema and its Port
4. Identifying key stakeholders
5. Developing visions
6. Voting on visions from the point of view of key stakeholders.

Documentation on the workshop process and outcomes was subsequently supplied to all participants.

Box 1: Game structuring method for stakeholder engagement workshops

3. OUTCOMES OF STAKEHOLDER ENGAGEMENT

The four activities comprising the stakeholder engagement process of the “Integrated and Sustainable Port Development in Ghana in an African Context” project to date have yielded:

- a composite story of the evolution of Tema from before the first port was constructed, to the present day and beyond;
- positive and negative visions for the future of the port and city of Tema;
- insights on the values held by local stakeholders in relation to these visions of the future;
- understanding of effects of the port development on the lives of local stakeholders.

4. CONCLUDING

The composite understanding of stakeholder values and port effects has enabled the subsequent identification of ecological, economic, infrastructural and social components that could potentially be used in the sustainable development of Tema and its port. In summary, grounded stakeholder engagement methods have proved vital in accessing local knowledge on how to improve the fit between the port of Tema and its social-ecological environment. We anticipate that local stakeholder inclusion and value-based design will prove equally important, and form a generic process-element, in a framework for sustainable development of ports in other localities in Ghana, Africa, and worldwide.

References

Cunningham, S. W., Hermans, L. M., Slinger, J. H. (2014). A review and participatory extension of game structuring methods. *EURO Journal of Decision Processes*, (DOI) 10.1007/s40070-014-0035-8

Cunningham, S.C., Kothuis, B.L.M., Slinger, J.H. (2015). Contested Issues Game structuring Approach (CIGAS). Game theory, real actors and values in the Houston Galveston Bay region. In: Kothuis et al. (eds.) *Delft Delta Design. Houston Galveston Bay Region. Texas, USA*. Pp. 58-59

NWO (2018). Integrated and Sustainable Port Development in Ghana within an African context, Urbanising Deltas of the World Program, URL: <http://www.nwo.nl/en/research-and-results/research-projects/i/95/13995.html> ; accessed February, 2018

Merk, O. (2013). The competitiveness of global port-cities: synthesis report. *OECD Regional Development Working Papers*, 2013(13)

Rodrigue, J. P., Comtois, C., & Slack, B. (2017). *The geography of transport systems*. New York, Routledge. ISBN 978-1138669574

Schipper, C. A., Vreugdenhil, H., de Jong, M. P. C. (2017). A sustainability assessment of ports and port-city plans: Comparing ambitions with achievements. *Transportation Research D* 57: 84-111. <http://dx.doi.org/10.1016/j.trd.2017.08.017>

Slinger, J. H., Cunningham, S. W., Hermans, L. M., Linnane, S. M., Palmer, C. G. (2014). A game-structuring approach applied to estuary management in South Africa. *EURO Journal of Decision Processes*. (DOI) 10.1007/s40070-014-0036-7

Slinger, J.H, Kothuis, B., Vreugdenhil, H., van der Kraan, A. (2017). Stakeholder Workshop, Tema, Ghana. Sustainable Port Development in Ghana within an African Context, NWO UDW Project W 07.69.206, 9 February 2017.

Vellinga, T., Slinger, J.H., Taneja, P., Vreugdenhil, H. (2017), Integrated and Sustainable Port Development in Ghana, SMTC 2017, 26-28 April, 2017, Singapore.

Vreugdenhil, H., Slinger, J.H., Keijer, H. Kothuis, B., Alink, A. Taneja, P., Vellinga T. (2016). Kick off Meeting and First General Workshop for Supporting Parties, Sustainable Port Development in Ghana within an African Context, NWO UDW Project W 07.69.206, 20 September 2016.

Acknowledgements

The Netherlands Organisation for Scientific Research (NWO-WOTRO) is acknowledged for financing project nr. W07.69.206 under the Urbanizing Deltas of the World programme. Our sincere gratitude is extended to all participants in the stakeholder engagement processes related to the Port of Tema.

THE CONTRIBUTION OF NATURE-BASED CONCEPTS TO SUSTAINABLE PORT DEVELOPMENT

by

J. Slinger¹, D. Rijks², T. Vellinga¹, P. Taneja¹, H. Vreugdenhil^{1,3}, W.P. de Boer^{1,3}, A. Kangeri⁴, B. Kothuis¹, M. Koetse⁵, L. Hagedoorn⁵, C. van Dorsser¹, E. Mahu⁶, B. Amisigo⁶, K. Appeaning Addo⁶

ABSTRACT

The potential added value of ecosystem-based concepts in port design are explored using a series of examples from the Netherlands and Ghana. The first example relates to the sandy dunes comprising part of the protection of the Maasvlakte II extension to the Port of Rotterdam. The second example focusses on enhancing the habitat suitability of bed protection, while the third example addresses improved connectivity and potential restoration of a brackish wetland adjacent to a recent harbor extension in Africa. The paper illustrates that the design of nature-based infrastructure requires a focus on opportunity creation and restoration of healthy ecosystems. Healthy ecosystems, in turn, help to ensure that benefits accrue to local as well as regional and global stakeholders in a port development process.

1. INTRODUCTION

Building with Nature is an ecosystem-based concept that specifically seeks to use natural materials, interactions and dynamic processes effectively in the design, realisation, operation and maintenance of hydraulic infrastructures (Waterman, 2010; Ecoshape, 2018). As such, it aims to identify and utilize opportunities to benefit nature while undertaking the infrastructural development of ports required to meet the trade, energy and development challenges of the future. This and similar concepts such as Working with Nature (PIANC, 2011) and Engineering with Nature (Bridges et al., 2016) are being applied in infrastructure design and construction around the world. Indeed, the concept is being implemented in practice in the Netherlands through an adaptive “learning by doing” approach. This paper provides examples of the use of nature-based concepts in port design, and highlights the potential of the approach by illustrating the connection of infrastructure design alternatives and the restoration of ecosystem services.

Since Costanza’s seminal work (Costanza et al., 1997), we have come to understand that healthy natural ecosystems provide services to individuals and to society (MEA, 2005; Bateman et al., 2013). These ecosystem services are considered to comprise production services (such as food harvesting), regulation services (such as flood control) and cultural services (such as recreation, spiritual significance). The ecosystem services concept is now widely used in identifying, quantifying and evaluating the effects of infrastructure design alternatives on the delivery of services to humans by the affected ecosystem. The use of ecosystem services to assess nature’s value constitutes a growing field of research over the past decade, and has been associated with the Building with Nature concept (Smith & Deerenberg, 2012).

¹ Delft University of Technology, Faculty of Civil Engineering & Geosciences, & Faculty of Technology, Policy & Management, Netherlands, j.h.slinger@tudelft.nl

² Royal Boskalis, Netherlands

³ Deltares, Netherlands

⁴ Wageningen Marine Research, Netherlands

⁵ Institute for Environmental Studies, Netherlands

⁶ University of Ghana, Department of Marine and Fisheries Sciences, Ghana

2. EXAMPLES OF NATURE-BASED ALTERNATIVES IN PORT DEVELOPMENT

A first example of a port-related and nature-based infrastructural project is the extension to the Port of Rotterdam, the Maasvlakte II, which is protected from coastal storm surge mostly by sandy dunes. The dune field enhances nature development, recreation and is simultaneously extremely effective and less costly than full protection by breakwaters. However, designing this option instead of a standard breakwater is not available to ports that are located on rocky coasts, or where sand is not readily available or could be damaging to ambient ecosystems such as coral reefs. An example of nature-based methods which could be relevant in such areas, draws on a study of the distribution of cavities (size and connectedness) in the bed-protection at the base of wind turbines. This study by Buijs (2015) investigated which size ratios of the rocks comprising the bed protection were best suited to the creation of appropriate cavities to shelter rock lobster in the North Sea. The outcomes yielded insight in the selection of rock size ratios, and indicated that the habitat suitability for rock lobster could be improved without significant additional cost. In addition to these two more general instances of ecosystem-based infrastructure design, the project "Integrated and Sustainable Port Development in Ghana in an African Context" (NWO 2018), has sought to extend the practice-based learning to a case study in Africa, namely the Port of Tema.

Preliminary investigative work on potential nature-based alternatives in the extension of the Port of Tema was undertaken by Vrolijk (2015). She identified the Sakumono Lagoon to the west of the harbour as a potential site for ecosystem restoration or opportunity creation, and this was confirmed through the stakeholder engagement process undertaken for the Tema case study (Slinger et al., 2018). At present, a multidisciplinary group of students from the Delft University of Technology is currently working with students and professors from the University of Ghana to design a number of interventions aimed at restoring this lagoon, or at the least effectively managing the water quality and habitat loss issues of this wetland area. partners and supporting parties (see Vellinga (2017) for information about the project organization) was held in Delft, the Netherlands, in September 2016 with similar objectives (Vreugdenhil, 2016). The Ghanaian researchers participated in the workshop through an active skype link. The workshop agenda incorporated an introductory presentation on the project, which included the input from the first workshop, a question and answer session, a personal mini-survey over what is (or is not) a sustainable port in Tema or an ideal world. This was then followed by group sessions on sustainable ports and general discussion. Then, the serious game Port of the Future was played as part of the workshop. This was done for parity with the stakeholder workshop in Ghana. Finally participants were asked to reflect on workshop. The outcomes were similar to the first workshop in Tema, namely increased awareness of sustainability and consensus on the most important issues to address via the project. In addition, the connectedness of the network around the project was strengthened, and the inputs and insights from the Ghanaian partners added depth to the discussion on sustainability within an African context.

The Sakumono II Lagoon is located very near to the furthest extension of the new breakwater of the expanded port of Tema. Currently the exchange of water with the sea is strongly curtailed as the connection only occurs through two large culverts extending under the coastal road. Given the anticipated increase in traffic to and from the expanded port it is understood that the road network around Tema will need to be developed. This is already happening with the connection between the Port and the main highway immediately to the north of the city of Tema currently being improved. However, the coastal road cannot lag far behind. Accordingly, preliminary designs for a bridge to replace the culverts and allow the free exchange of marine and freshwater through the mouth of the Sakumono II Lagoon are being investigated in collaboration with scientists from the project Integrated and Sustainable Port Development in Ghana in an African Context. Restoring the connection would restore continuity of water flow and sediment exchange and re-establish a brackish environment. Following Slinger (2000), it is anticipated that after some adjustment time, involving dieback of the freshwater vegetation that has colonized the lower reaches of the lagoon, the flora and fauna characteristic of a brackish wetland would re-establish. However, it is not sufficient to simply restore water exchange. The wetland is subject to high nutrient loading from waste effluent and has experienced decades of sediment infilling owing to reduced flushing and landfill for settlement.

Additional interventions such as dredging and nutrient management (cf. Taljaard et al., 2017) would also be required if opportunities for nature, and concomitant ecosystem services benefits, are to be realised. These benefits include increased livelihood fishing opportunities for the fisherman of Sakumono village (to the west of Tema) whose marine fishing grounds have decreased with the expansion of the harbour. Additionally, the residents on the upstream eastern bank of the lagoon may be flooded less frequently. At present they are suffering flooding on an annual basis in the wet season as the constricted mouth causes back-flooding. A nature-based approach focussed on the restoration of ecosystem processes, so as to once again permit the delivery of production and regulatory ecosystem services, would simultaneously restore the aspects of the cultural services. The Sakumono II Lagoon holds spiritual significance for the indigenous peoples of the area.

3. IN CONCLUSION

In this paper, we have illustrated that the design of nature-based infrastructure requires a focus on opportunity creation and restoration of healthy ecosystems. This helps to ensure that benefits accrue to local as well as regional and global stakeholders in a port development process.

References

- Bridges, T.S., Banks, C.J., Chasten, M.A. (2016). Engineering with nature. Advancing system resilience and sustainable development. *The Military Engineer*, January-February 2016: 52 – 54. https://ewn.el.erdc.dren.mil/Publications_files/Publications/Pub%201%20EWN%20TME-JanFeb2016.pdf#view=fit
- Buijs, W. (2015). Ecology-based bed protection of offshore wind turbines. MSc thesis, Delft University of Technology, Delft, The Netherlands. <http://repository.tudelft.nl/view/ir/uuid:13e98ca5-bc9b-4935-ab85-8aa03593fc88>
- Bateman, I.J., Harwood, A.R., Mace, G.M., Watson, R.T., Abson, D.J., Andrews, B., Binner, A., Crowe, A., Day, B.H., Dugdale, S., Fezzi, C., Foden, J., Hadley, D., Haines-Young, R., Hulme, M., Kontoleon, A., Lovett, A.A., Munday, P., Pascual, U., Paterson, J., Perino, G., Sen, A., Siriwardena, G., Van Soest, D.P., Termansen, M., (2013). Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom. *Science* 341, 46–50.
- Costanza, R., R. d'Arge, R. de Groot, S. Faber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. v. d. Belt. (1997). The value of the world's ecosystem services and natural capital. *Nature* 387:253-260.
- Ecoshape (2018). Building with Nature, www.ecoshape.nl ; accessed 3 March 2018.
- Millennium Ecosystem Assessment, (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.
- NWO (2018). Integrated and Sustainable Port Development in Ghana within an African context, Urbanising Deltas of the World Program, URL: <http://www.nwo.nl/en/research-and-results/research-projects/i/95/13995.html> ; accessed February, 2018
- PIANC (The World Association for Waterborne Transport Infrastructure). (2011). PIANC Position Paper 'Working with Nature', www.pianc.org/workingwithnature.php ; accessed 19 September 2016.
- Slinger, J.H. (2000). Decision support for the conservation and management of estuaries. Final report of the predictive capability sub-project of the co-ordinated research programme. WRC Report No. 577/2/00, Water Research Commission, Pretoria, South Africa. 132 pp + appendix. ISBN 1 86845 635 8.

Slinger, J., P. Taneja, B. Kothuis, H. Vreugdenhil, W.P. de Boer, A. Kangeri, M. Koetse, L. Hagendoorn, C. Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo, T. Vellinga (2018). Designing for stakeholder values in port development in Africa. Presented at PIANC 2018, 7 – 11 May 2018, Panama city, Panama.

Smith, S.R. & Deerenberg, C. (2012). A ranking of coastal EU habitat types using Ecosystem Services. IMARES report C159/12.

Taljaard, S., van Niekerk, L., Slinger, J.H. (2017). A screening model for assessing water quality in small, dynamic estuaries. *Ocean and Coastal Management* 146: 1-14. <http://dx.doi.org/10.1016/j.ocecoaman.2017.05.011>

Vrolijk, E. (2015). Ecosystem-based port design. An approach for sustainable development. MSc thesis, Delft University of Technology, Delft, The Netherlands. <http://repository.tudelft.nl/view/ir/uuid:5aa8c5bd-37ef-47f1-8fdd-20114ecc576e>

Waterman, R.E. (2010) Integrated coastal policy via Building with Nature. PhD thesis, Delft University of Technology, Delft, The Netherlands.

Acknowledgements

The authors wish to acknowledge the Netherlands Organisation for Scientific Research (NWO-WOTRO) for financing this research project (nr. W07.69.206) under the Urbanizing Deltas of the World programme. Sincere gratitude is expressed to the Delft Deltas, Infrastructures & Mobility Initiative (DIMI <https://www.tudelft.nl/infrastructures/>) Special Project Ghana Volta Delta for their support.

DIFFUSING KNOWLEDGE ON SUSTAINABLE PORT DEVELOPMENT

by

J. Slinger¹, H. Vreugdenhil^{1,2}, P. Taneja¹, W.P. de Boer^{1,2}, A. Kangeri³, B. Kothuis¹, M. Koetse⁴, L. Hagedoorn⁴, C. van Dorsser¹, E. Mahu⁵, B. Amisigo⁵, K. Appeaning Addo⁵, T. Vellinga¹

ABSTRACT

This paper adopts theory on pilot projects to devise a strategy for the diffusion of new knowledge and practices from case study research on an African port. Progress in disseminating knowledge and in creating awareness of new practices is reviewed. The efficacy of the strategy is also assessed.

1. INTRODUCTION

Pilot projects are policy instruments for introducing or testing innovative approaches, concepts or technologies, and can be viewed as stepping stones in the development of new practices (Vreugdenhil et al., 2012). Pilot projects can also stimulate the wider acceptance and implementation of new practices. In a study on pilot projects in water management, Vreugdenhil (2010) identified that the diffusion of new knowledge and practices from pilot projects can occur in four ways:

- i) Inclusion of the pilot project in routine project practice (routinization)
- ii) Replication of the pilot project at other locations, in different social-ecological contexts, but at similar scale (replication)
- iii) Scaling-up of the pilot project to larger spatial or temporal scales (expansion)
- iv) Institutionalization of the pilot project approach at higher organisational, sectoral or cross-sectoral levels (institutionalization).

Since the main aim of the project “Integrated and Sustainable Port Development in Ghana in an African Context” (NWO 2018) is to develop knowledge and test design practices for integrated and sustainable ports in an African case study, namely the Port of Tema in Ghana, it is feasible to view the case study endeavour as a research pilot project. This allows us to apply the theory on pilot project diffusion to stimulate the wider dissemination and uptake of the new knowledge and practices developed within the research project.

2. DESIGNING AN INFLUENCE STRATEGY

Because of the long term nature and the high level of investment involved with port development, it is unlikely that port development projects will be routinized. Accordingly, we have adopted two of the four mechanisms for diffusing new knowledge and practices as the basis for our influence strategy (Figure 1). We envisage that the port development pilot project to have a potential ripple effect within Ghana itself, resulting in the replication of (elements of) our case study approach within other potential Ghanaian port development projects (Phase 1 to 2 in Figure 1). We do not anticipate an expansion of the pilot project itself as our inclusive, ecosystem-based approach is broad and has already identified and addressed key strategic issues and key stakeholders from the outset (Taneja et al. 2018; Slinger et al., 2018). We actively seek to disseminate knowledge and procedures from the pilot project to institutionalize the approach within African port development (Phase 2 to 3 in Figure 1), by informing and involving national and pan-African decision makers on harbour

¹ Delft University of Technology, Faculty of Civil Engineering & Geosciences, & Faculty of Technology, Policy & Management, Netherlands, j.h.slinger@tudelft.nl

² Deltares, Netherlands

³ Wageningen Marine Research, Netherlands

⁴ Institute for Environmental Studies, Netherlands

⁵ University of Ghana, Department of Marine and Fisheries Sciences, Ghana

development in our project where possible (indicated by the upper arrows). We expect this form of pilot project diffusion to be crucial to the ultimate impact of the research project, and will support this by specific networking and dissemination activities. In this way other African case studies will be able to add knowledge, concepts and practices in a bottom-up way and through active Pan-African port and shipping networks. Note that whereas Phase 1 and 2 lie entirely within the scope of the project, the full impact in Phase 3 extends beyond the project lifetime.

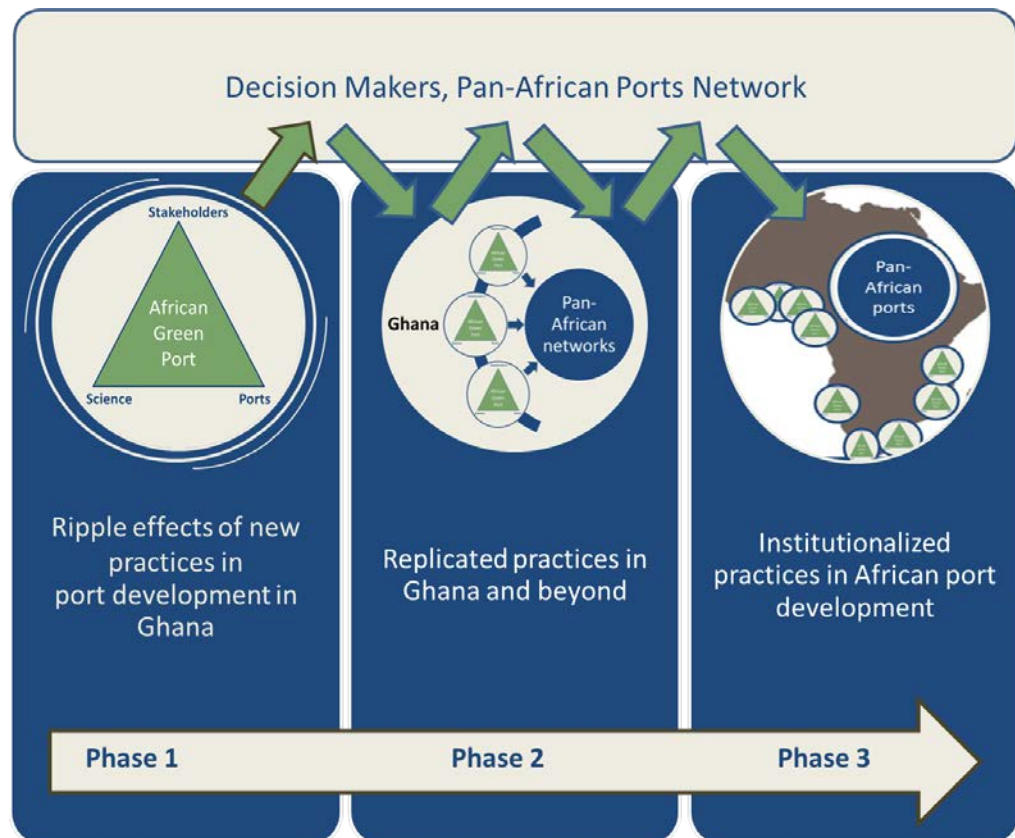


Figure 1: Following the initial development of new port development practices in a pilot project case in Ghana, the replication of practices within Ghana and beyond is envisaged as is the eventual institutionalization through bottom-up adoption and Pan-African networks (NWO, 2018).

The following active communication initiatives were undertaken to enhance knowledge diffusion and the subsequent uptake of research results in the form of new practices for sustainable port design.

- A project website was created <http://sustainableportsafrica.com/> with the name “Building a Blueprint for Sustainable Ports in Africa”, for facilitating systematic documentation and widespread and easy sharing of project findings.
- A flyer was printed to promote the project Sustainable Ports in Africa.
- A popular article with the title “De duurzaamste haven van Afrika (the most sustainable port in Africa)” was published online in March 2017 (http://waterviewer.tudelft.nl/world#/de-duurzaamste-haven-van-afrika-1489499617271_) in which various members of the research team (Tiedo Vellinga, Mark Koetse and Arno Kangeri) discussed aspects of stakeholder-inclusive design in Africa.

In addition, presentations were given at conferences attended by port engineers and developers in an effort to sensitize engineers and developers to new practices in port infrastructural design and port development (Vellinga et al., 2017; Slinger et al. 2017; Kangeri, 2017; Vellinga, 2017; Slinger 2017). The conferences included SMTC 2017, 26-28 April, 2017, Singapore, the MARE Conference 2017 in Amsterdam and the African Ports Evolution Conferences for West Africa, in Ghana, and for Southern and Eastern Africa, in Durban, South Africa.

A number of project reports, papers and two masters' theses were also produced within the first year to one and a half years of the project. The Masters theses focussed on aspects not addressed within the main research project, but that had been identified by stakeholders as relevant issues during the stakeholder engagement process. These included the feasibility of an inland water container transport service between Tema and Lake Volta (Toebes, 2017) and the effect of port development on the urban dynamics of Tema city (van den Houten, 2017).

Cross-linkages with on-going projects were also sought, namely:

- Collaboration with the Delft Deltas, Infrastructures & Mobility Initiative (DIMI <https://www.tudelft.nl/infrastructures/>). The Sustainable Ports in Africa project will contribute to the objectives of DIMI through a Ghana special project on the Volta River Delta and Tema Port in which a multi-faculty education & research collaboration and integrated design approach is applied by a student group.
- Collaboration with researchers from the Deltas, Vulnerability & Climate Change: Migration & Adaptation project (DECCMA <http://www.geodata.soton.ac.uk/deccma/>).

3. CONCLUDING

On reflection, each of the activities was designed to grow the network aware of the concept of sustainable ports, to share knowledge, disseminate research and initiate uptake activities. This influence strategy has been effective to date, and as a result, the research is already known within a much wider network. The network includes port engineers and developers active in other regions in Africa and incorporates other research endeavours such as DECCMA and DIMI. Indeed, the anticipated uptake and testing is already occurring with the CSIR in South Africa agreeing to comment critically on the applicability of the methods developed within the Tema case study in their port stakeholder-engagement processes.

It remains to influence policy makers towards more sustainable port development and to truly establish a Sustainable Ports in Africa network. This will form the major focus in our ongoing efforts to disseminate new knowledge and practices within the African context..

References

Bridges, NWO (2018). Integrated and Sustainable Port Development in Ghana within an African context, Urbanising Deltas of the World Program, URL: <http://www.nwo.nl/en/research-and-results/research-projects/i/95/13995.html> ; accessed February, 2018.

Kangeri, A. (2017), Frameworks for Harbor Sustainability in Africa, MARE Conference 2017, People & the Sea IX: Dealing with Maritime Mobilities, 5-7 July, 2017, University of Amsterdam, the Netherlands.

NWO (2018). Integrated and Sustainable Port Development in Ghana within an African context, Urbanising Deltas of the World Program, URL: <http://www.nwo.nl/en/research-and-results/research-projects/i/95/13995.html> ; accessed February, 2018.

Vellinga, T. (2017), Integrated and Sustainable Port Development: Making a conscious choice for man, environment and economy, African Ports Evolution- west African edition, 5-6 September 2017, Accra, Ghana

Slinger, J. (2017). Sustainable ports in Africa: An integrated “Building with Nature” approach to co-create value at the port-city nexus. African Ports Evolution Conference 2017, Durban, 17-18 October 2017.

Slinger, J., Taneja, P., Vellinga, T., van Dorsser, C. (2017), Stakeholder inclusive design for Sustainable Port Development in Africa, SMTC 2017, 26-28 April, 2017, Singapore.

Slinger, J., P. Taneja, B. Kothuis, H. Vreugdenhil, W.P. de Boer, A. Kangeri, M. Koetse, L. Hagendoorn, C. Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo, T. Vellinga (2018). Designing for stakeholder values in port development in Africa. Presented at PIANC 2018, 7 – 11 May 2018, Panama City, Panama.

Taneja, P., T. Vellinga, J. Slinger, H. Vreugdenhil, W.P. de Boer, A. Kangeri, B. Kothuis, M. Koetse, L. Hagendoorn, C. Dorsser, E. Mahu, B. Amisigo, K. Appeaning Addo. (2018). Towards a framework for integrated, ecosystem-based port development. Presented at PIANC 2018, 7 – 11 May 2018, Panama City, Panama.

Toebe, K. (2017). Pre-feasibility of an inland water container transport service at lake Volta, Ghana, MSc thesis, Delft University of Technology, Delft, the Netherlands.

van den Houten, J.(2017). A System Dynamics Exploration of Port-City Development: the Case of Tema, Ghana. MSc thesis, Delft University of Technology, Delft, the Netherlands.

Vellinga, T., Slinger, J., Taneja, P., Vreugdenhil, H. (2017), Integrated and Sustainable Port Development in Ghana, SMTC 2017, 26-28 April, 2017, Singapore.

Vreugdenhil, H. S. I. (2010). Pilot projects in water management. Practising change and changing practice. PhD thesis, Delft University of Technology, Delft, the Netherlands.

Vreugdenhil, H., Taljaard, S. and Slinger, J.H. (2012). Pilot projects and their diffusion: a case study of integrated coastal management in South Africa, Int. J. Sustainable Development, Vol. 15, Nos. 1/2, pp.148–172.

Acknowledgements

The authors wish to acknowledge the Netherlands Organisation for Scientific Research (NWO-WOTRO) for financing this research project (nr. W07.69.206) under the Urbanizing Deltas of the World programme. Sincere gratitude is expressed to the Delft Deltas, Infrastructures & Mobility Initiative (DIMI <https://www.tudelft.nl/infrastructures/>) Special Project Ghana Volta Delta for their support.