Presentation at the Port Environment & Sustainability visit by Director Generals of African Ports 25 -27 September 2019, The Netherlands

INTEGRATED AND SUSTAINABLE PORT DEVELOPMENT WITHIN AN AFRICAN CONTEXT

Tools for Port Planning - A Case Study of Port of Tema

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S.P. AFRICA
SUSTAINABLE PORTS IN AFRICA
Key features and innovations Maasvlakte 2

- Working/building with respect for nature
- Stakeholder inclusive & co-creation of values
- Integrated adaptive design
- New knowledge
- Green growth
Integrated and Sustainable Ports in Ghana in an African context Research NWO- Urbanising Deltas of the World

Project features

• Balance between morphological, economic, ecological and social processes

• Interdisciplinary co-creation with African stakeholders

• Bottom-up approach from practical cases into tools and a generic framework
Integrated and Sustainable Ports in Ghana in an African context

Project partners

- TU Delft
- University of Ghana
- UNESCO-IHE Delft
- WUR / Imares
- VU - Amsterdam
- Deltares
- WWF
- NABC (Netherlands African Business Council)*

Budget 700,000 euro (incl. 4 postdocs (0.5), and researchers from Ghana) 4 years
Proposal approved start project May 2016.

*Soskalis, Van Oord, IHC, Damen Shipyards, Port of Amsterdam, Deep BV, STC, FMO, CWT Sitos, MTBS
The societal, economic and management challenges

Port of Tema, Ghana

- Flood risk
- Eroded beaches
- Lagoon under pressure
- Crowded fishing port
- Existing port
- New port development area
Workshop in Accra-Tema Ghana, Juli 2015
Research lines

1. Storybook
2. Coastal Morphology e.g. Coastal Erosion and Port Layouts
3. Ecosystem changes
4. Ecosystem services
5. Governance
6. Hinterland connections

Towards a framework for sustainable port development

- \( T_{-1} \) Historic development
- \( T_0 \) Existing port (status quo)
- \( T_1 \) Proposed expansion
- \( T_{1^+} \) Incremental value addition (green port)
- \( T_{1^{++}} \) Out of the box (green port ++)
Project outcomes

• **Framework**
  • Best practice guidelines for implementing integrated and sustainable port development in Africa
  • Scientific papers

• **Tools**
  • Quick design tools using remote sensing data and integrating ecological data
  • Tried and tested methods for stakeholder-inclusive port planning, including game structuring workshops

• **Green Ports Africa Network**
  • A community of researchers, private sector practitioners and port-related stakeholders
Sustainable Ports Framework

overarching co-design process

- Value-based
- Stakeholder-inclusive
- Ecosystem-based
- Future-proof

Port design hierarchy

1. Alternatives to port development
2. Port site
3. Port layout
4. Structures & Materials

Systemic elements of the approach
Integrated engineering design
Methods & selection criteria

contextualize

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Designing for stakeholder values in port development in Africa
Approach

- Place-based
- Stakeholder-inclusive
- Ecosystem-based
- Value-based
- Design-oriented
- Bottom-up
- Aiming to meet societal, economic & management challenges

Transdisciplinary, game structuring approach
### Context

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>DIMI Ghana</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Feb</td>
<td>Research team travel to Ghana</td>
<td></td>
</tr>
<tr>
<td>5 Feb</td>
<td>Field trip along the coast to Tema</td>
<td>Observation, engagement</td>
</tr>
<tr>
<td>6 Feb</td>
<td>Mini-symposium with researchers</td>
<td>Knowledge integration</td>
</tr>
<tr>
<td>7 Feb</td>
<td>Data acquisition and interviews</td>
<td>Developing system understanding</td>
</tr>
<tr>
<td>8 Feb</td>
<td>Data acquisition, interviews, preparation</td>
<td>Stakeholder-inclusive, value-based design</td>
</tr>
<tr>
<td>9 Feb</td>
<td>Multi-stakeholder Workshop</td>
<td></td>
</tr>
<tr>
<td>10 Feb</td>
<td>Academic follow-up meeting</td>
<td>Feedback, Integration</td>
</tr>
</tbody>
</table>
6-Step Workshop

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

Spler et al. (2014)
Cunningham et al. (2014)

Who are we?
What do we care about?
Who cares?
Visioning
Valuing
#1 Getting acquainted: map exercise
#2 – Developing the system story: Local stakeholders on past, present, future Tema
#2 – Developing the system story: Local stakeholders on past, present, future Tema
#3 Developing the system story: Researchers on Tema and its Port

- Tema Coastal System
  - Kwasi Appeaning-Addo, Wiebe de Boer
- Coastal Ecosystem Response to Change
  - Edem Mahu, Arno Kangeri
- Values Associated with Ecosystem Services
  - Mark Koetse, Barnabas Amisigo
#4: Who cares? Identifying key stakeholders

1. Civil society organizations
2. Private Sector
3. International
4. Education and Research
5. Ministry of Transport & Agencies
6. Local and Traditional
7. Ministries
8. Environmental Regulators
9. Politicians
#5 – Developing future visions

1a. Cool Africa

- Economic interests and ecology are in balance although there is limited land, growing population
- Improved transportation including an inland port
- Estuaries are designated as a critical habitat e.g. sakumono, Chemu lagoons
- GPHA incorporates the lagoon systems into their development, in an ecologically sensitive way
- Meridian Rock will also act as a artefact of tourist interest
- Tema wastewater treatment sewage system is broken now, but then it will be working
- Tema administration needs to be fixed
- Port development – 10 million euros
- Offshore docks will be linked by rail systems to the mainland and hinterland
- 5°C water from deep sea will be used to cool facilities and improve export potential
1b. Cannabalism

- Chemu and Sakumono lagoons have almost vanished
- No humans are living in Tema or near the port
- Containers abound
- There is cannabilism, as food is short and only port development counts
#5 – Developing future visions

2a. State of the Art

- Gateway terminal with low waiting time for goods by maritime transport
- Terminals outside the port
- Little travel time for port employees
- Direct link to the national road network, good roads, dedicated lane for port traffic
- Good rail network
- Cranes that can work on both road and rail, rather than one or the other
- Cross modal transport system
- Link to Volta via canal
- Fully automated cranes and gates, CCTV cameras and systems to regulate access and direct you to where you want to go
- Port has own tram system
- All waste well managed
- Residential areas close to the port with affordable housing (for port workers)
- Hovercraft to attract tourists, local people as tourists
- Port not only for cargo, also for passengers and local people
- Experienced as a State of the Art port

2b. Madness

- Polluted environment
- Bad drainage and visible sewerage
- Congested traffic
- State interference
- Duplication of functions
- Slum development
- Human traffic into the port
- More security offices at the port – there are too many now.
- Depicted on the upper part of the picture above
#6 – Voting on the visions
Coastline evolution around African seaports from space:

ports as element of coastal system
(Eco-)Engineering context & focus
Relevance

Coastal erosion can cause:
• Undermining of coastal infra
• Increased flood risk
• Loss of property
• Ecological habitat loss

Coastal accretion can cause:
• Increased ingress in ports and access channels (dredging costs)

Hence, important for people, planet & profit!

De Jong et al., 2015)

Google Earth, 2018)
How to screen for alternatives: Towards planning & design guidance
Approach

• Generate evidence database of coastline evolution adjacent to African seaports
• Assess coastline evolution with satellite imagery (data poor environment)
• Cross-compare ports based on coastline evolution and characteristics
Approach: coastline evolution (CE)
## Approach: port characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Parameters/classification</th>
<th>Method/source</th>
<th>Time (period)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longshore sediment transport (LST)</td>
<td>Wave climate ($H_s$, MWD)</td>
<td>ERA-Interim reanalysis data (ECMWF)</td>
<td>1984-2018</td>
</tr>
<tr>
<td>potential ($H_{2.5}^s \sin(2\pi)$)</td>
<td>Coastline orientation</td>
<td>Manually from latest available GE image</td>
<td>2018</td>
</tr>
<tr>
<td>Sediment sources &amp; sinks</td>
<td>Presence of rivers/inlets</td>
<td>Visual inspection of latest available GE image</td>
<td>2018</td>
</tr>
<tr>
<td>Natural sheltering setting</td>
<td>Open coasts</td>
<td>Visual inspection of latest available GE image</td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>Headland-bay coasts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural barriers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal protection</td>
<td>None</td>
<td>Visual inspection of latest available GE image</td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>Dominated by CS structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dominated by LS structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakwater length</td>
<td>Shore-normal distance between the landward and seaward breakwater tips</td>
<td>Manually from latest available GE image</td>
<td>2018</td>
</tr>
<tr>
<td>Port construction date</td>
<td>Date of visible port structures</td>
<td>Visual inspection of Landsat time lapse</td>
<td>1984-2018</td>
</tr>
</tbody>
</table>
Results African seaports: CE

- For all 130 ports:
  - 44.2 km² areal change
  - 23.4 km² accretion
  - 20.8 km² erosion
- Top 10% determine 65%
- Top 1 determines 13%

<table>
<thead>
<tr>
<th>Top 10 historic evolution</th>
<th>Areal change (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nouakchott, Mauritania</td>
<td>5.9</td>
</tr>
<tr>
<td>Cotonou, Benin</td>
<td>4.3</td>
</tr>
<tr>
<td>Port Said, Egypt</td>
<td>3.6</td>
</tr>
<tr>
<td>Damietta, Egypt</td>
<td>3.1</td>
</tr>
<tr>
<td>Lomé, Togo</td>
<td>2.6</td>
</tr>
<tr>
<td>Monrovia, Liberia</td>
<td>1.5</td>
</tr>
<tr>
<td>Laayoune, Morocco</td>
<td>1.3</td>
</tr>
<tr>
<td>Richards, Bay, South Africa</td>
<td>1.2</td>
</tr>
<tr>
<td>Lagos, Nigeria</td>
<td>1.2</td>
</tr>
<tr>
<td>Buchanan port, Liberia</td>
<td>1.1</td>
</tr>
</tbody>
</table>

76,000 Landsat satellite images over past 34 years
Results CE vs characteristics

Large coastline evolution if:
- Large LST potential
- Located @ open coast
- Sediment sources & sinks nearby
- Cross-shore coastal protection works present
- Large (shore-normal) breakwaters
- Constructed longer ago

### Table: Results CE vs characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of ports (%)</th>
<th>Gross coastal areal change $\Sigma$ (%)</th>
<th>Share of ports with net accretion (%)</th>
<th>Share of ports with net erosion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wave power - LST potential</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$0.55$ (m$^2$)</td>
<td>35%</td>
<td>10%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>$\geq 0.55$ (m$^2$)</td>
<td>65%</td>
<td>90%</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td><strong>Sheltering setting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open coast</td>
<td>56%</td>
<td>88%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Headland-Bay</td>
<td>30%</td>
<td>9%</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>Behind natural barriers</td>
<td>14%</td>
<td>3%</td>
<td>44%</td>
<td>56%</td>
</tr>
<tr>
<td><strong>Sources &amp; sinks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37%</td>
<td>58%</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>No</td>
<td>63%</td>
<td>42%</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td><strong>Protection structures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No structure</td>
<td>68%</td>
<td>40%</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Longshore structures</td>
<td>11%</td>
<td>5%</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Cross-shore structures</td>
<td>21%</td>
<td>55%</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Construction date</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After 1984</td>
<td>29%</td>
<td>25%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Before 1984</td>
<td>71%</td>
<td>75%</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Breakwater length</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;400 (m)</td>
<td>28%</td>
<td>7%</td>
<td>51%</td>
<td>49%</td>
</tr>
<tr>
<td>$\geq 400$ (m)</td>
<td>72%</td>
<td>93%</td>
<td>69%</td>
<td>31%</td>
</tr>
</tbody>
</table>
Lessons learnt

- Coastline evolution adjacent to ports can be an issue
- Small share of ports (hotspots) determines large share of CE; for large share limited issues
- Characteristics related to large CE: LST potential, sources & sinks, sheltering, protection works, BW length (affects site/layout selection -> planning/design)
- Note that not all relevant characteristics are included in this study (limited by data availability)
- Remote sensing gives opportunities for (1) observations in data poor environments and (2) large-scale inter-comparisons
Framework implications: site/lay-out

- Port behind a breakwater
- Offshore berth
- Open port
- Port behind an (artificial) island
Questions

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