

LOME CONTAINER TERMINAL AND COASTAL EROSION

SHORT TERM ASSIGNMENT

ARTELIA Eau & Environnement
MARITIME Business Unit

6 rue de Lorraine
38130 – Echirolles - France
Tel.: +33 (0) 4 76 33 40 00
Fax: +33 (0) 4 76 33 43 33

N°871 4529 – Short term assignment report					
LOME CONTAINER TERMINAL AND COASTAL EROSION					
V3	Minor revision (technical vocabulary)	LHM	LHM	LHM	15/07/2016
V2	Final version	ELC	LHM	LHM	13/07/2016
V1	English version	ELC	LHM	LHM	11/07/2016
V0	Draft	ELC	LHM	LHM	07/07/2016
Version	Description	Drawn up by	Checked by	Approved by	Date

CONTENTS

1. OBJECTIVE OF THE ASSIGNMENT	1
2. SUMMARY AND CONCLUSIONS	1
2.1. QUESTION 1: IS THERE SUFFICIENT INFORMATION?	1
2.2. QUESTION 2: EXPERIENCE AND EXPERTISE OF BOTH INROS LACKNER AND EGIS	2
2.2.1. INROS LACKNER	2
2.2.2. EGIS	3
2.3. QUESTION 3: ARE THE MITIGATING MEASURES RECOMMENDED IN THE ESIA APPROPRIATE?	3
2.4. QUESTION 4: IS THERE ANY EVIDENCE TO SUGGEST THAT THE EXTENSION OF THE TERMINAL LED TO INCREASED COASTAL EROSION AND BY HOW MUCH?	3
3. DETAILED ANALYSIS OF THE ESIA	4
3.1. THE PROJECT	4
3.1.1. SAND-INTERCEPTING GROUYNE	4
3.1.2. DISPLACEMENT OF MATERIAL	4
3.2. THE ISSUE OF EROSION	5
3.2.1. SEDIMENTARY ACCUMULATION WEST OF THE PORT	5
3.2.2. EROSION EAST OF THE PORT	6
3.3. PROJECT IMPACTS DURING THE WORKS PHASE	7
3.3.1. CONSTRUCTION OF THE GROUYNE	7
3.3.2. PLACING OF FILL AND DEEPENING OF THE BASIN AND ACCESS CHANNEL	7
3.4. PROJECT IMPACTS DURING THE OPERATION PHASE	8
3.5. OVERALL ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN	8
3.5.1. ENVIRONMENTAL MEASURES DURING THE CONSTRUCTION PHASE WITH REGARD TO EROSION EAST OF THE PORT	8
3.5.2. ENVIRONMENTAL MEASURES DURING THE OPERATION PHASE	8
3.5.3. SUMMARY OF BEST PRACTICES	8
4. OTHER DOCUMENTS	9
4.1. NUMERICAL MODELLING	9
4.2. EXPERT APPRAISAL REPORT BY EGIS	10
4.3. PRELIMINARY DESIGN STUDY OF COASTAL PROTECTION	11

1. OBJECTIVE OF THE ASSIGNMENT

The port of Lomé was built in the 1960s and quickly led to coastal erosion in the area to the east of the port, with this phenomenon continuing to this day.

Works to extend the port of Lomé (new container terminal) were carried out between 2011 and 2012. The communities living in the coastal fringe area east of the port have complained about the acceleration of the erosion process in the past few years, a phenomenon that could be attributed to the recent works. Have these works really contributed to increasing coastal erosion in the area located to the east of the port?

The International Finance Corporation (IFC, a subsidiary of the World Bank Group) commissioned Artelia on 1 July 2016 to perform the present assignment. The objective is:

- To check the four documents that were prepared initially in the context of the project to extend the container terminal in Lomé, Togo (including the creation of basin 3 and of a sand-intercepting groyne),
- To draw up a critical analysis of the impacts on coastal erosion for the area located to the east of the port,
- To answer this question, which induces three other more specific questions, which will also be addressed in the present document.

The following documents provided by the IFC were reviewed as part of the assignment:

1. "Lomé Container Terminal (LCT) – *Etude d'Impact Environnemental et Social (EIES) du projet*" (Environmental and social impact assessment (ESIA) for the project). Inros Lackner, Sept 2010 (in French);
2. "Lomé Container Terminal (LCT) - *Etudes océanographiques pour la conception du terminal à conteneurs au port de Lomé, Modèle mathématique pour la conception d'un épi d'arrêt de sable*" (Oceanographic studies for the design of the container terminal at the port of Lomé, Mathematical model for the design of a sand-intercepting groyne). Inros Lackner, 2009 (in French);
3. "Extension Project of the Port of Lomé, Impacts on the coastline, Expertise report, Version 2". EGIS, January 2016;
4. "*Projet de protection du littoral du Togo du PK 0.0 au PK 50 contre l'érosion côtière, Etude technico-économique et sociale pour les mesures à court, moyen et long termes de lutte contre l'érosion côtière, Phase 1 – Etude technique et sociale, Avant-Projet Sommaire (APS)*". (Project to protect the coast of Togo against coastal erosion from PK 0.0 to PK 50. Technical, economic and social study for short-, medium- and long-term measures to fight against coastal erosion, Phase 1 – Technical and social study, preliminary design study) Inros Lackner, August 2014 (in French).

2. SUMMARY AND CONCLUSIONS

2.1. QUESTION 1: IS THERE SUFFICIENT INFORMATION?

The precise question has been formulated as follows: "Is there sufficient information (most of it can be found in the Inros Lackner documents) to make the determination that the construction of a 300 m groin at the entrance to the harbour did not accelerate coastal erosion to the east of the port of Lomé?"

Enlarging the view

The question could be rephrased to avoid limiting the assessment to the issue of the groyne, and to take into account all the components of the construction works as indicated in the table 26 (page 144) of the ESIA report:

- replenishment of the beach in front of the new basin (dredging of the basin);
- construction of the spur groin;
- raising of the area (dredging of the basin and/or sand extracted at sea);
- deposition/immersion of sediment;
- dredging for deepening the new basin, the existing port and its access channel;
- other activities during the construction of the terminal and mitigation measures.

Effective lack of information

The analysis of the documents showed that a certain amount of information is missing. The essential data missing are listed below. We should like to point out that the study currently being performed by Artelia on behalf of the ADB (complementary studies for preparing the project to reinforce climate resilience for infrastructure in Togo's coastal areas), which addresses the same topic, did not provide this missing information.

The information required concerns the following aspects:

- Aspects relating to operating the port: existence of maintenance dredging operations, resources used, volume of dredged material, location of dredging operations, frequency, dumping of dredged material (location, depending on the type of sediment dredged),
- Aspects relating to the options actually adopted for the works:
 - Sediment movement and displacement: volumes involved in nourishing the beach in front of the basin, origin of the fill material (excavated material, dredged material, extractions at sea, etc.),
 - Dumping of demolition material: volumes involved, location of the dumping site(s),
- Aspects relating to the impact reduction/mitigation measures recommended in the ESIA:
 - What has really been done to protect the east coast?
 - Are the changes in terms of coastline retreat (east coast) being monitored in the context of these measures? Can we obtain reports on this topic from port authorities?

2.2. QUESTION 2: EXPERIENCE AND EXPERTISE OF BOTH INROS LACKNER AND EGIS

2.2.1. Inros Lackner

Opinion on major aspects:

1. For the "determination of baseline conditions" aspect: Inros Lackner had sufficient experience and expertise to characterise the baseline conditions. In particular, they had assessed correctly the impacts of the developments on the halting of the longshore drift (without however mentioning the sand trap that the port access channel represents); they also documented the coastline retreat east of the port correctly.
2. For the "project design" component: the standard solutions proposed are not necessarily fully adapted to the local context of each site. The level of the study performed by the sub-contractor (Matheja Consult) on coastal modelling aspects is poor, and Inros Lackner would not appear to have made a critical analysis nor obtained validation of this study by a

competent person. The documents we have reviewed don't enable us to conclude if Inros Lackner had sufficient experience and expertise in project design to be able to perform this task.

3. For the "impact assessment": we have noted the absence of any specific studies; no models of changes in the coastline have been implemented.

From the foregoing, it may be concluded that Inros Lackner has good skills in terms of summarising existing information, but that it has not shown credible skills with regard to the hydrosedimentary consequences of their design, both for the port extension project and for the project to protect the east coast of the port (lack of discernment and application of standard solutions).

2.2.2. EGIS

Egis demonstrated good skills in terms of summarising and providing a critical analysis of the documents consulted and we agree with their conclusions.

Coastal modelling is not part of their expertise.

2.3. QUESTION 3: ARE THE MITIGATING MEASURES RECOMMENDED IN THE ESIA APPROPRIATE?

The ESIA report suggests three mitigating measures:

1. Use of part of the demolition material (recovered during cleaning and stripping of the project zone) to provide local protection to the east of the port;
2. Discharge of sand at sea, close to the east coast of the port (sediment dredged in the context of works to deepen the port basin and the access channel);
3. Regular inspection of the periods and locations chosen to dump dredged material, in order to make sure these operations are efficient and to monitor the possible impacts on siltation and erosion of the Togolese coast and take measures if necessary.

Points 2 and 3 are the most important aspects compared to point 1, which concerns one-off occurrences.

These measures seem appropriate to us, subject to their being designed and implemented properly. In particular, discharging sand close to the coast must be the subject of a detailed prior design study in order to avoid potential adverse impacts (creation of a shoal that would concentrate waves, sand placed too far offshore, in particular off the beach-rock plateau).

2.4. QUESTION 4: IS THERE ANY EVIDENCE TO SUGGEST THAT THE EXTENSION OF THE TERMINAL LED TO INCREASED COASTAL EROSION AND BY HOW MUCH?

In the context of the preliminary design study of coastal protection, carried out by Inros Lackner in August 2014, i.e. after the works had been carried out, no mention is made of recent data concerning monitoring of the impacts of the project on the east coast, nor is there any analysis of the change in the coastline.

The report focuses on the impacts of storm events and their consequences on the coastline, in particular the storms that took place in 2012 and 2013 (which "took inhabitants by surprise, especially at night").

These storms (which occurred after completion of the project) resulted in significant coastline retreat, as Artelia was made aware of during the launch assignment and the visit of the coast

carried out in the context of its study on behalf of the African Development Bank. It is likely that local populations may have attributed this erosion (or at least part of it) to the port extension project.

It should also be pointed out that the recent data and analyses concerning changes in the coastline east of the port, which resulted from Artelia's study, do not indicate any increase or decrease in the retreat of the coastline, except for an erosional "hot spot" in the area of Baguida in the period between 2013 and 2015¹ and prior periods (2002-2013 and 1988-2002/07).

3. DETAILED ANALYSIS OF THE ESIA

3.1. THE PROJECT

With regard to measures that could potentially have an impact on coastline dynamics and on sediment transport, the project involved creating a sand-intercepting groyne and displacing dredged material for the new basin.

3.1.1. Sand-intercepting groyne

The justification of the sand-intercepting groyne (§ 3.2.2) is based on the fact that, in spite of sand extraction operations during the port construction works (ore carrier quay platform, jetty 2) and the constant extraction of sand for constructing buildings in the city, sand accretion along the coastline between the border with Ghana and the port has continued unabated; the shore has now reached the bend of the main jetty and will soon go round it; if no particular measures are taken, the sand will then move towards the access channel and thus reduce its depth.

The construction of a 300 m long sand-intercepting groyne, planned in the context of Phase I of the project, will prevent sediment deposition in the access channel.

Insofar as the beach has been artificially pushed out seawards (platform construction operations using sand extracted during the excavation of the basin) in order to create the basin and protect it from the impacts of the sea, **this justification is not satisfactory.**

The functional design of the groyne is based on insufficient information, which we could even describe as misleading or unsupported.

3.1.2. Displacement of material

This concerns the creation of the harbour platforms, dredging operations and dumping of dredged material.

The paragraph relating to the technical description of the new container terminal (§ 3.1.) states that the sand required to build the platform area (2 m depth approximately) could be:

- Extracted at sea (sand deposit located in a westward area, between the site of the former Lomé Wharf and the former Hôtel de la Paix, at a depth of approximately 20 m (information repeated in §6.3.1.3) and pumped to the site using a suction dredger and an outlet pipe, or
- Taken from the site itself.

¹ Given the short period of time between 2013 and 2015 and the potential seasonal variations related to the dates on which photos were taken, the average change rates estimated for the 2013-2015 period must be taken with precaution and must not be considered as representative of a long-term trend in coastline evolution.

A few lines further on, it is written that the material dredged from the new port basin (but also from the manoeuvring area and port access channel, if necessary) will be used for the works included in phase I, such as the hydraulic fill on the sea side, or **dumped east of the port**. For phase I (540,000 m² platform), the volume of sand required amounts to approximately 1.2 million m³.

During phase 3, a volume of 1.7 million m³ of sediment obtained from dredging operations at -16.6 m ZP in the new basin, the port basin and the access channel, or transported and **dumped into the sea close to the shore subject to erosion**. An alternative suggested would be to dump this sediment in deep waters.

The project also made provision for part of the demolition material generated by project zone stripping and cleaning works to be transported and dumped in the erosion zone. The ESIA report specifies (in §3.2.3 and §6.3.1.2) that after sorting, these materials (concrete blocks, breeze blocks, etc.) will be used to protect – albeit temporarily – the coastline that is subject to erosion.

No maps have been provided showing the location of zones where dredged material will be dumped, sites where demolition material will be deposited, or information on the resources used in this respect. Furthermore, it would be useful to know the options that were ultimately selected.

It should be specified that breaking waves driving the longshore drift have an impact on the beach profile evolution down to a certain depth. Given the type of waves in the area this depth (depth of closure) is less than the depth of the access channel. In this sense, the access channel represents a virtually impassable barrier for sand coming from the west, as long as the channel depth remains less than the depth of closure. The sand originating from the west can be deposited into the channel but cannot be lifted back into suspension by waves and currents from the other side.

3.2. THE ISSUE OF EROSION

The ESIA report mentions the existence of a national programme for controlling coastal erosion, elaborated in 2007, which is aimed notably at protecting areas threatened by erosion, as well as monitoring and assessing the consequences of erosion.

The report refers to the oceanographic study performed in the context of the project in 2009, the said study being based on surveys carried out on site; it specifies that the current regime in front of the port was described precisely and that the study confirms the west-east coastal drift and explains this phenomenon by the fact that sediment put into suspension by breaking waves mainly coming from the south-west is transported eastwards by the current induced by these waves.

The report states that already during the planning stage of the port around 1960-62, two morphological behaviour patterns for the beach could be expected (all the drawings of the port showed this phenomenon): accumulation of sediment west of the port, and relatively significant erosion to the east. These forecasts were confirmed following the construction of the port as of 1964-67 (comparison of coastal monitoring operations carried out before and after the construction of the port).

This phenomenon can be explained by the fact that the port protection breakwater played the role of a long groyne coming out of the wave-breaking zone and intercepted all the longshore drift for a certain number of years.

3.2.1. Sedimentary accumulation west of the port

The report recounts the results of many observations (cf. § 5.1.4.) carried out in the context of operations to monitor coastline changes and assess the impact of the construction of the port basin's main breakwater on the west coast:

- Blocking of sediment transport along the shore; the sand, which migrates from west to east and is transported by the longshore drift, is blocked by the breakwater and deposited on the west side (deposited volume amounting to approximately 1.5 million m³ per year) since 1967.
- Gradual growth of the zone west of the port following natural siltation and reclamation of zones, in spite of the extraction of large quantities of sand on the occasion of various port infrastructure construction projects (construction of the backfilled ore carrier quay platform, the jetty 2 and the breakwater for the clinker cement terminal).

It also specifies that GPS tracking carried out since 2005 indicates that sand continues to accumulate west of the breakwater. However, the intensification of sand extraction operations (nearly 1.2 million m³ in the accumulation zone) is curbing the extension of the offshore bar in this location.

The report mentions that following the recent installation of the coastal protection system in Keta, Ghana (several groynes placed perpendicular to the shore), the volume of sand deposited on the Togolese west coast seems to have decreased, at least temporarily until a new equilibrium is found.

3.2.2. Erosion east of the port

Concerning erosion east of the port of Lomé, the report indicates that **“already during initial planning of the port, Togolese authorities were aware that building the port would entail significant erosion to the east, behind the port location, because of the obstacle that the port would form with regard to the coastal sedimentary current”**.

The decision to build the port was therefore taken in full knowledge of the facts. All the drawings at the time already showed a precise 700 m wide and approximately 10 km long zone located to the east of the port as being subject to predictable erosion that **would make this zone unsuitable for future construction projects**.

The erosion was logically confirmed shortly after construction of the port. Despite the fact that the erosion zone had been established in advance, processing industrial facilities, trading houses, shops, stadia, hotels and restaurants were built close to the shore; they are now surprised at the impacts of coastline retreat.

The data on erosion are then discussed in the report: these data were mainly taken from work by Professor Blivi (CGILE/University of Lomé, 2008), who, based on monthly monitoring of the coastline, showed that the east coast between the port (PK 11) and Aného (PK 48) has always been subject to coastline retreat since the construction of the port (“the principal cause is the impact of the main breakwater at the port of Lomé on longshore drift”).

It is specified that the rate of retreat is particularly significant between Katanga and Afiadégnigba (PK 11 / PK 25), where it ranges from 10 m to 120 m over the period between 1985 and 2008; the rate of retreat fluctuates between 2.5 and 8 m/year, depending on the year and the occurrence of more or less violent storms. The extent of erosion also depends on the presence or not of beach-rock (that can contribute to blocking sediment exchanges in the profile and may therefore play a role in the hydrosedimentary mechanism resulting in a slowdown or an acceleration of impacts on the beach).

We can therefore conclude that the issue of coastal erosion east of the port was widely known and that it is described accurately by Inros-Lackner in this ESIA report.

What is not described in the report is the description of mitigating measures that consist in transferring sand mechanically from the accumulation zone to the west and in the channel towards the eroded beaches to the east.

3.3. PROJECT IMPACTS DURING THE WORKS PHASE

3.3.1. Construction of the groyne

The ESIA report indicates that with regard to siltation to the west of the port: “the impact of the construction of the groyne (§6.3.1.1) on wave regimes and sediment transport was analysed in detail in the oceanographic studies (September 2009) carried out by Inros-Lackner”. The report states that “to prevent sediment from entering the port basin, the Togolese authorities had accepted that an annual volume of approximately 1.25 million m³ of sand was extracted from the accumulation zone. This corresponds approximately to the total estimated amount of sediment transported parallel to the shore (1.5 million m³).”

With regard the persistence of erosion to the east of the port, the report specifies that “in the current situation, i.e. with no sand-intercepting groyne, coastal erosion to the east of the port will always be perceptible because the continuing commercial extraction of sand in the siltation zone stops sediment transport nearly completely along the coast and around the main breakwater. Likewise, the existence of the groyne – coupled with a halt in sand extraction – will have a similar impact since the groyne will also stop sediment transport.

The report concludes that **construction of the sand-intercepting groyne will not result in a major change in the current rate of erosion**. During the initial phase following the extension of the groyne, a slight increase in erosion cannot be ruled out.

Since erosion to the east of the project zone will not change significantly, **there will be no impact”**.

These conclusions, even if they are likely, are not backed up with concrete arguments. It is therefore an expert’s opinion. We cannot say that the report comprises a genuine impact study of this groyne on the east coast.

3.3.2. Placing of fill and deepening of the basin and access channel

The documents states (§6.3.1.3) that the impact of sand extraction (assuming a suction dredger is used to extract approximately 1.2 million m³ of sand from the sea at a depth of 20 m, off the coast of the sector between the former Wharf and the former *Hôtel de la Paix*, the sand being discharged in the zone to be backfilled) will not affect sediment transport along the coast.

There is no evidence that justifies this assertion, even if it is likely; in addition, no mention is made of the risks of potential changes to wave propagation conditions caused by the changes in seabed depths following the removal of this volume of sediment and the possible consequences on the coastline.

During the next extension phases, the new basin, the access channel and the current port basin will need to be dredged (1.65 million m³ of sediment to be removed); provision is made for the sediment obtained from dredging operations at -16.6 m ZP to be transported and dumped into the sea, close to the shore, in the erosion zone. An alternative mentioned in the report would be to deposit this sediment in deep waters.

It is indicated, in the corresponding chapter (§6.3.1.8), that material dredged from the port is currently transported to the erosion zone close the coast east of the port.

It would be appropriate to determine if any maintenance dredging operations have actually been carried out by the port, in particular in the access channel and the entrance to the port. If that is the case, the sites used to dump maintenance dredging material should be specified.

The report follows on with the claim that, should dredged material be dumped in the erosion zone east of the port, similar impacts to those resulting from dumping maintenance dredging material

from the current port – albeit more significant – will be induced in the erosion area east of the port, with the sediment temporarily reducing local erosion east of the port if it is dumped in the vicinity.

There again, no evidence justifying a slow-down in erosion to the east (similar to the statement about the positive impacts of dumping maintenance dredging material from the port) is provided, even if it is likely.

The option consisting in dumping the dredged material further offshore is taken into consideration (considered as “less advantageous compared to dumping it very close to the shore) but no mention is made of the impacts on erosion to the east for this specific case.

The report does not specify what solution was selected in the end.

3.4. PROJECT IMPACTS DURING THE OPERATION PHASE

The “Project impacts during the operation phase” **does not mention the issue of coastal erosion to the east of the port.**

3.5. OVERALL ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

3.5.1. Environmental measures during the construction phase with regard to erosion east of the port

The report (§7.4.2) specifies that “**construction of the terminal will not have a major influence on the current erosion east of the port. Erosion could even be curbed temporarily** because of:

- Dumping in the erosion zone of demolition material obtained from stripping and cleaning operations of the project zone, which will slow down the erosion phenomenon;
- Dumping into the sea (but very close to the shore that is being eroded) of sediment dredged in the context of port basin and access channel deepening works.”

and that “these two measures will require detailed planning and regular monitoring of the dumping periods and locations in order to assess their efficiency”.

3.5.2. Environmental measures during the operation phase

No mention is made of any measures taken in relation with the erosion issue.

We will repeat here what is said above in the document: “the programmes relating to construction of the sand-intercepting groyne and the backfilled platform in the zone are combined with monitoring measures to detect potential impacts on siltation and erosion along the Togolese coast”. (end of §3.2.4).

3.5.3. Summary of best practices

In short, the impact assessment for this kind of development must involve the creation of models coupled with solid expertise. This could be:

- A movable bed scale model²,

² Lagroy de Croutte E. (1992). "Aménagement des accès au canal de Vridi (Port d'Abidjan) et protection du littoral de Port-Bouët (Côte d'Ivoire)". Ouvrage "La Coopération Française et la Mer". Collection "Focal Coop" du Ministère de la Coopération et du Développement,

- The combination of a 1D numerical model to determine the changes in coastline (ashore of the wave-breaking zone) and a 2D numerical model to study the changes in sea beds beyond the wave-breaking zone.

These models must follow a precise calibration process and calibration validation protocol, as recalled in § 4.1 below. Furthermore, these models must also be used to check the positive or negative impact of mitigating measures. For example, these models must be used to check if dumping sand in shallow areas in front of the erosion zones will actually nourish the beach or if it will create a focus for the power of the waves, thereby creating an erosional “hot spot” (adverse effect to avoid).

4. OTHER DOCUMENTS

4.1. NUMERICAL MODELLING

The study was sub-contracted by Inros Lackner to design office Matheja Consult. The model comprises a hydrodynamic section (levels, currents, waves) and a morphodynamic section (transport of sandy sediment, seabed modifications). The field data that were used to develop the model are not described clearly. Reference is made to a report by IWA (2009) for the currents, a report by Alkyon (2003) for waves, and a report by Geotech (2009), which we do not have at our disposal.

The report is difficult to understand because of **the use of the French language without respecting the profession’s technical vocabulary.** Evidently, it is a (bad, probably machine-generated) translation of a report drawn up in another language. In these conditions, it is difficult to give a precise opinion on the validity of its conclusions.

Example of a conclusion phrase (in French), which was incomprehensible, on page 35: “*Le profil de la courbe de sédimentation devient irrégulier en cas de remplissage de puits terrassés. C'est-à-dire que les mécanismes de sédimentation sont activés ultérieurement dans un endroit à plus haute altitude*”.

Regarding the hydrodynamic model:

- It seems to be correct for water levels with a satisfactory calibration with tide gauge measurements carried out in the port of Lomé.
- The section on currents is incorrect for several reasons: the boundary conditions imposed to the west are constant, regardless of tide, wind and wave conditions. The velocity is validated over the mean measured value over a daily period whereas the currents alternate.
- The section on waves is not described in the report but the boundary condition used (1.15 waves with significant wave height of 1.5 m; 10.5 s period for waves coming from the south (N180°)) do not correspond to a representative wave for the site according to our own estimations. A direction closer to N190° that would drive the longshore drift from west to east should have been considered.

The morphodynamic model was not developed in compliance with traditional industry standards, which include:

- An analysis of field data over a historical period for which data are available. In our case, these data exist and concern the coastal advance on the west side, the coastal retreat on the east side, and the dredging operations in the access channels and the basins in the port of Lomé;

- Breakdown of this historical dataset into two sub-periods in order to calibrate and then validate the model;
- An iterative calibration phase of the sedimentary parameters of the model in order to adjust the model as closely as possible to changes during sub-period no. 1;
- A parameter-definition validation phase by way of calculations concerning sub-period no. 2.

The duration of the morphodynamic simulation, which was one year, is not at all sufficient to assess the functional efficiency of this kind of groyne; no evidence justifying the reason for choosing this short period is provided in the report.

The sand nourishment process resulting from dredging operations in the new basin is not taken into account in the present model.

The results provided in the initial situation in the form of an erosion-siltation map (appendix 2) seem unrealistic, with persistent erosion along the west coast, which is the opposite of the field observations, that reveal significant siltation. Another erosion process, at the western boundary of the map, is also incomprehensible. This could be due to the position of the western boundary of the model, which is too close to the port. However, the precise boundary of the model is not stated clearly. Such discrepancies between field data and the model cast a doubt on all the results provided. Furthermore, the maps of the results provided, showing different groyne configurations, are not sufficient to make an impact assessment: they should also have provided a comparison of these maps and a comparison with the baseline conditions to assess the impact of an alternative.

Regarding specifically the impact of a groyne on the east coastline, the formal conclusion of the report is the opposite of the calculations. Indeed, the conclusion indicates that “To the east of the port, the erosion on the down-drift side that has been observed in the baseline conditions, will be slightly reduced following the diversion of the current running parallel to the coast (Appendix 2 and Appendix 3, points 8 and 9)”, whereas on point 9 of the graphs provided, we can see an acceleration of erosion. This was also pointed out in the expert appraisal report drawn up by Egis.

4.2. EXPERT APPRAISAL REPORT BY EGIS

Following a review of the different documents made available, Egis studied the issue of erosion of the east coastline and that of the impact of the port extension works. It then drew up recommendations regarding the quality, comprehensiveness and relevance of the data provided.

Concerning the ESIA, we wish to highlight the following points:

With regard to the conclusion in which it is stated that “the project will have no impact on the current situation, except maybe just after the construction of the groyne, when there could be an increase in erosion; the east side of the coast will still be subject to erosion in the following years”: with the information it had at its disposal, Egis validates this conclusion and points out that the study is not really focused on erosion issues along this coast and that certain aspects were not described and analysed sufficiently.

In this respect, the assessment made by Egis is in line with our conclusions.

In terms of insufficiently exploited data, data that would have been useful to gain a better understanding of changes in the coastline, the role of meteorological and oceanographic conditions and that of human action on coastal changes, and also to draw up a more precise assessment of the potential impacts of the project, Egis mentions the following:

1. the impact of the beach rock on the rate of coastal changes,
2. a more precise assessment of sand and marine aggregate extraction activities,
3. information on siltation of port basins and the access channel, on maintenance dredging operations and on the fate of dredged material,

4. bathymetric data,
5. lack of a traditional 1D modelling study of coastline changes.

Concerning point 3 above, Egis mentions the existence of a more recent document (Svasek, 2013), based on a numerical simulation, which indicates siltation rates amounting to nearly 400,000 m³/year for the baseline conditions (prior to the extension works) and 300,000 m³/year after the construction of the 300 m long groyne.

Egis also comments on the lack of justification/documentation for a certain number of aspects, which is consistent with Artelia's opinion. These aspects concern: the lack of a significant impact of the project on erosion to the east, the fate and impact of fine sediment dumped to the east, the lack of any information on the impact of extracting 1.2 million m³ of aggregates/sand in the sea, the fact that the impact of dumping demolition material would have a very localised impact.

4.3. PRELIMINARY DESIGN STUDY OF COASTAL PROTECTION

At the beginning of its preliminary design study report, Inros-Lackner mentions (§2.1) “the considerable impact of the breakwater on longitudinal sediment transport, with the development of a siltation zone west of the port, while significant erosion was noticed immediately after the construction works, to the east of the port”.

It recalls that this coastal erosion phenomenon was taken into consideration in the plans to construct the deep-water port. In this context, the suggestion not to construct anything on a 600 m wide strip had been made, but this recommendation was not respected.

It also specifies that coastal erosion to the east of the port is not uniform. During a long period spanning several years, “not many changes occur, meaning that the erosion phenomenon is not significant and that, during a storm, a 20 m wide (or maybe more) coastal strip could disappear (like for example in 1984)”.

In its description of the current situation (§2.2), it indicates:

- To the west, the shore close to the Ghanaian border is stable but depending on the season, erosion can occur in certain places (like in July 2014), and further east the coastline is advancing, due to the port structures.
- To the east of the port, the different sections are described from west to east as far as the border with Benin, including: the level of urban development on the coastal area, the qualitative description of erosion phenomena, the presence and impact of structures, the presence and influence of the beach rock on erosion, the damage observed, etc.; it is recalled that erosion on the Togolese coast, from the east of the port to the city of Aného, is extremely diversified.

The report specifies that “with the construction of the sand-intercepting groyne (2012) and the banning of sand extraction, siltation in front of the port towards the west will increase considerably and **the erosion phenomenon to the east of the port will increase**”. This double assertion is not backed by any justifying evidence and **the assertion that the erosion phenomenon to the east of the port will increase is not consistent with the rest of the ESIA report.**

In chapter 3, which addresses the “Attempt to describe coastal erosion in Togo”, the introduction starts with the following sentence: “In the past few decades, and **more specifically in the past few years, the Togolese coast has been subject to significant erosion**, which ...”.

Several causes for the erosion – natural and/or human – are then specified. Beyond the impact of human activities in the port of Lomé and the dam on the river Volta (which transports sediment), the report mentions in particular sand and marine aggregate extraction by populations living along the river, which has been going on for many years and more extensively in recent times, because of an increase in the demand in construction material (sand extraction in the coastal area has been

banned since then), the impacts of storms that are getting increasingly powerful and sudden, and the issue of sea level rise.

The position of the current coastline compared to that of 1986, the average coastal retreat for different sections of the shore and the expected coastline position by the year 2030 are then indicated (§3.2.) for different scenarios (results of a model for which no details are given).

The report specifies (§3.2.3.) the effects of storms and their consequences on the coast, for example in 1984, 2004, 2008, 2010 and more recently 2012 and 2013, which “took inhabitants by surprise, especially at night”.

The report specifies (end of §3.4.2) that the Togolese government, through its Ministry of the Environment, commissioned several general studies on the issue of erosion and on practical approaches for consolidating the coast at specific locations. A vulnerability map of the Togolese coast was produced (Tenou, 2006).

The next chapters present the protection solutions suggested for the entire east coast in the context of this preliminary design study. These standard solutions mainly consist in installing short groyne (roundheads located inside the wave-breaking zone) to stabilise the coast once the groyne are saturated.

o0o