Vulnerability of North-African towns to climate change: coastal risks.

Dominique Cataliotti[1], Yves Ennesser[2] and Monique Terrier[3]

[1]Egis Eau, 78 allée John Napier, 34965 Montpellier Cedex 2, dominique.cataliotti@egis.fr
[2]Egis Eau, 78 allée John Napier, 34965 Montpellier Cedex 2, yves-ennesser@egis.fr
[3]BRGM, 3 avenue C. Guillemin, 45060 Orléans Cedex 2, m.terrier@brgm.fr

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Introduction

The coastal cities of Middle East and North Africa (MENA region) currently host over 60 million inhabitants and will home almost 100 million by the year 2030. These megalopolises are both the most productive and the mostly threatened by climate change impacts urban areas, particularly on account of their being coastal. According to some experts, this region is expected to be the second one mostly affected by Accelerated Sea-Level Rise (ASLR). So there is an urgent need to assess the risks and sources of urban vulnerability in the region, in order to strengthen the resilience of the cities concerned.

As part of the CMI (Centre for Maritime Integration) « cities and climate change » Programme, managed jointly by World bank and CDC, Egis, IAU-IDF and BRGM are working together to assess the current state of preparedness for natural disasters and climate change, of three North-African large towns : Alexandria, Tunis and Casablanca (and Bouregreg valley in Rabat), and Algiers Wilaya (17 cities) coast. The recently completed diagnostic phase clarified the erosion and coast submersion risk levels, currently and by the year 2030. The analysis was supplemented by a tsunami risk assessment.

The main components of the methodological approach and the results on the most representative sites are set out below.

A methodological approach suited for the study scale and uncertainty.

Due to the length of the coast studied (several tens kilometres, up to one hundred for Alexandria and Algiers Wilaya) it was necessary to develop a simple and robust method for the risk analysis and simulations.

As regards coastal erosion issues, the approach relied primarily, besides some locally conducted studies, on a diachronic analysis of vertical black-and-white paper photographs (contact sheets). Thus the results from four photographic missions were used to chart the changes of the Tunis coastline from 1948 up to the present day. For Algiers Wilaya coastline, the analysis used the results of the AIS SMAPIII (2006-2008) project where five photographic missions from 1959 up to 2003 were studied.

As no study of marine submersion issues on the concerned urban areas as a whole had previously been achieved, the analysis began with an assessment of exceptional sea surges. The characteristics of the major storms that impacted the Tunisia, Morocco and Egypt shores during the last decades were defined from literature surveys and talks with maritime and port authorities. Thus the fifty-year events were assessed for these Mediterranean sites. The impact of the corresponding surges in terms of submersion was estimated through Digital Terrain Modelling (DTM).
These DTM were based on the different topographic computer data available, including the ones resulting from the Grand Tunis submersion study (BCEOM, SIRIUS, 2005) and the Development and Town Planning Masterplan of Grand Casablanca (IAU-IDF, 2006).

Their accuracy is about 10 cm on a vertical axis. Note that due to the geographic scale and the resource constraints, field verifications were not possible. Therefore the identified areas are the « potentially » submersible ones, without prejudice to most of the natural or artificial obstacles (e.g. road embankment) that might protect some parts of them. Nevertheless the main protection dikes were taken into account. On the Algiers Wilaya coast, in the absence of data, the extreme surge was computed, without return period estimation, in reference to the design of a protection infrastructure close to the town of Bab-El-Oued by the MEL (Marine Engineering Laboratory). But due to the lack of topographic data it was not possible to build a DTM, so the impact of surges was estimated by experts.

The Accelerated Sea Level Rise (ASLR) by the year 2030 was estimated from extensive analysis of the recent scientific literature in the field. The 4th IPCC report controversial positions were compared to other authors' more pessimistic forecasts. A basin based analysis was performed with a view of improving the projections on the Mediterranean area. Note that the local tide recordings could not be used to identify the level trends, because the available recording period was too short (Tunis) and/or some relatively strong subsidence phenomena are observed (Alexandria), and/or lack of data (Algiers Wilaya). A 20 cm sea level rise was adopted for year 2030. The impact of sea level rise on surges was estimated. Due to the insufficient accuracy of the DTM on the coastline and the lack of bathymetric surveys, it was impossible to quantify the impact of ASLR on erosion phenomena; consequently the analyses performed were only qualitative. The natural sensitivity of the shore (depending on sandy beach widths and slopes), the existing or projected infrastructures, the protection challenges (present or planned dense urban seafronts, protected natural area…) were nevertheless taken into account in the analysis; then a mapping with three risk levels (low, medium, high) was proposed. As for submersion, the global risk mapping was supplemented with water level simulations on GIS along the shores where a DTM was available.

The seismic risks were added to the climate ones, notably through the interpretation of the scenario of a possible tsunami that could impact the sites studied within 20 or even 50 years. The evaluation is based on the compilation and analysis of events data banks, and on the simulation results of fictive earthquakes, located in tsunamigenic areas related to the coasts studied. Yet it was not possible to compare them directly to meteorological submersions, because of the lack of bathymetric charts sufficiently detailed for simulating tsunamis propagation.

Some results aimed at raising local stakeholders' awareness.
Some examples of results from these studies are given below. They attest to the willingness to draw the attention of local policy-makers upon the risk and vulnerability of coastal urban areas in the climate change context. They should be considered only as a first review of the topic, marked out to be subsequently completed and refined. They are already being discussed with local land planners with views to set up action plans to reduce the climate change impact within the 20 years to come. Before mapping out the risk areas, the value of risk depending on hazard and issues is estimated. The resulting table indicates « theoretical » levels that must be modulated and adapted to the different coasts. Of course this analysis is subjective.

		Issues		
		Low	Medium	High
Erosion	Low	Low risk	Medium risk	Medium risk
	Medium	Low risk	High risk	High risk
	High	Medium risk	High risk	High risk
Submersion	Low	Low risk	Low risk	Medium risk
	Medium	Low risk	Medium risk	Medium risk
	High	Medium risk	Medium risk	High risk

Then the risk is mapped to assess the evolution of the length of the coast concerned by ASLR. Thus along Algiers coast, ASLR results in 7% erosion and 2% submersion high risks increases by the year 2030.

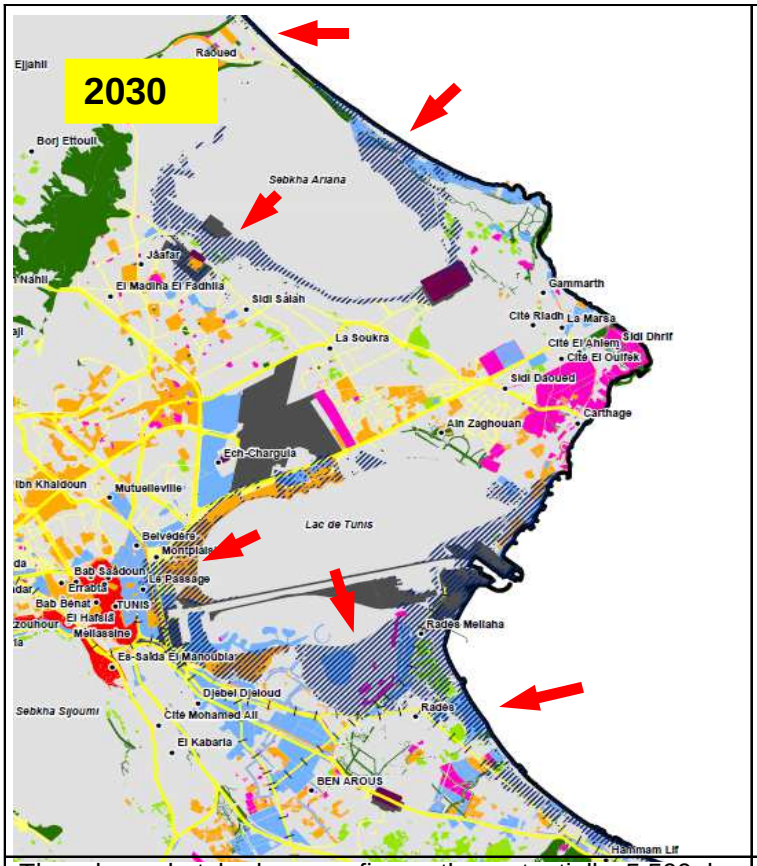
	High	Medium	Low
Erosion risk	22.4%	62.2%	15.4%
Submersion Risk	13.1%	73.6%	13.3%

Algiers Wilaya coastlines by risks class as currently recorded

	High	Medium	Low
Erosion risk	29.5%	56.6%	13.9%
Submersion Risk	15.2%	71.5%	13.3%

Algiers Wilaya coastlines by risks class, as expected by year 2030

For Tunis coast a high erosion risk on 16 km of coastline currently appears, and 27 km in 2030, resulting from sea level rise (+20 cm), but mostly from coastal urbanization. Sea submersion risk is high for the whole coast but also on the banks of Tunis lake and Sejoumi and Ariana sebkhas.



The above hatched areas figure the potentially 5.500 ha submerged by a 50-year sea surge by year 2030 (1.34 m, official Tunisian level references). The red arrows figure the sectors were the submersion risk is increasing most. The main urban vulnerabilities are figured by specific colours.

The erosion risk map by the year 2030 results from the crossing of erosion hazards map and sensibility map ; the latter results from the crossing of socio-economic and heritage components.

Conclusion

The present study provides concrete findings in terms of coastal risk assessment in a climate change context, for an operational horizon consistent with urban programmes (2030) and for a longer term strategic planning horizon. It reveals that by 2030, compared to the current situation, in the case of a 50-year storm, the submerged surfaces and the high erosion risk coastline should increase respectively by 22% and 70% in Tunis; the impact is significantly lower all along Algiers Wilaya coast. In Alexandria, the deterioration of the semi natural beaches of the west part of the city coast will mainly result from the urban extension. The economic cost of these risks is estimated at the significant annual average value of about 20 million Dinars by the year 2030 (that is to say about 0,04% of Grand Tunis GDP), of which 22 % due to climate change.

Note that this study is exploratory in nature: it is the first one of this kind in North-African countries, ir provides an assessment at both operational and strategic levels, it includes both climate and climate (tsunami) risks, etc… Even if a number of uncertainties remain, first regarding sea level rise hypotheses, it helps become more aware of the coastal areas urban development issues, and constitutes a decision support tool for the territory stakeholders.