Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa

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<tr>
<td>AAC</td>
<td>Average Annual Cost</td>
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<tr>
<td>AASTMT</td>
<td>Arab Academy for Science, Technology and Maritime Transport</td>
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<tr>
<td>B/C</td>
<td>Benefit/Cost ratio</td>
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<tr>
<td>BRGM</td>
<td>Bureau de Recherche Géologique et Minière</td>
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<tr>
<td>CBA</td>
<td>Cost-Benefit Analysis</td>
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<tr>
<td>CC</td>
<td>Climate Change</td>
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<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
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<td>EBI</td>
<td>Egis BCEOM International</td>
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<td>EEAA</td>
<td>Egyptian Environmental Affairs Agency</td>
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<td>EMS98</td>
<td>European Macroseismic Scale 1998</td>
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<td>ESA</td>
<td>European Space Agency</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GFDRR</td>
<td>Global Facility for Disaster Reduction and Recovery</td>
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<tr>
<td>GIS</td>
<td>Geographical Information System</td>
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<tr>
<td>IAU-IDF</td>
<td>Institut d’Aménagement et d’Urbanisme d’Île de France</td>
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<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<tr>
<td>LYDEC</td>
<td>Lyonnaise des Eaux de Casablanca</td>
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<tr>
<td>MENA</td>
<td>Middle East and North Africa</td>
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<tr>
<td>MSK</td>
<td>Medvedev-Sponheuer-Karnik seismic scale</td>
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<td>MSL</td>
<td>Mean Sea Level</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<td>NTF-PSI</td>
<td>Norwegian Trust Fund for Private Sector and Infrastructure</td>
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<td>ONCF</td>
<td>Office National des Chemins de Fer</td>
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<td>RPP</td>
<td>Risk Prevention Plan</td>
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<td>SDAU</td>
<td>Schéma Directeur d’Aménagement et d’Urbanisme</td>
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<td>SMBA</td>
<td>Sidi Mohammed Ben Abdallah</td>
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<td>SONEDE</td>
<td>Société Nationale d’Exploitation et de Distribution des Eaux</td>
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<td>TFESSD</td>
<td>Trust Fund for Environmentally &amp; Socially Sustainable Development</td>
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<tr>
<td>ToR</td>
<td>Terms of Reference</td>
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<td>U.S. Geological Survey</td>
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Chapter 1 – Introduction

1. Reminder of the Framework and Objectives

The World Bank is increasing its assistance to Governments in the MENA region to face the growing threats of climate change and natural disasters, and to incorporate appropriate responses in their development plans. As a result, a study on Climate change adaptation and natural disaster preparedness in the coastal cities of North Africa was launched in 2008, financed by the World Bank and by the fiduciary funds NTF-PSI, TFESSD and GFDRR managed by the World Bank.

The study is one of the foundational programs of the Marseille Center for Mediterranean Integration (CMI). Created in 2009, the CMI is a regional knowledge and learning platform supporting evidence-based public policy choice. Its urban programs support dialogue, new knowledge and its use among the public and decision-makers. The study will provide the basis for further work under the programs. Its program on "cities and climate change" focuses on urban vulnerability to climate change, climate-appropriate urban development, and energy efficiency in buildings. Its services include policy workshops, guidance materials, studies and advisory services to the countries of the Southern Mediterranean and of the Arab world.

The study focused on three North African coastal cities: Alexandria in Egypt, Tunis in Tunisia, Casablanca in Morocco, and on the Bouregreg Valley between Rabat and Salé in Morocco, where a major urban development project is being planned and implemented. The choice has fallen on those four urban sites following an interaction with national and local authorities, which have expressed a great interest in the study.

The competitive selection of the consulting firm in charge of the technical work for the study was concluded in May 2009, in favour of the consortium Egis Bceom International / IAU-IDF / BRGM. The contract has been carried out between June 2009 and June 2011. The consulting consortium interacted with national and local authorities, while the World Bank team maintained the policy dialogue and coordinating role with respect to the local and national counterparts and supervised the implementation of the technical studies.

The main objectives of the study were:

1. Assessing the climate change and natural disaster vulnerabilities of the four urban locations by the 2030 horizon. The main outputs consist of: a) providing updated and exhaustive scientific assessments of future climate change and sea-level rise, and probabilistic risk assessment of natural disasters; b) conducting an in-depth analysis of the geological, topographical, hydrological, and environmental nature of the four sites; c) assessing the current urban coverage and the vulnerability of the urban infrastructure assets present on the sites; d) projecting the growth of the urban agglomerations at the 2030 horizon based on the current demographic and urbanization trends; e) constructing multi-layered GIS urban vulnerability maps based on the previous tasks; f) evaluating the socio-economic costs of the impacts of climate change and natural disaster risks in the four urban locations; and g) assessing the roles and activities of national and local institutions in the urban planning, infrastructure provision and disaster preparedness relevant to the four urban locations.
2. Formulating action plans to improve their adaptation to climate change and preparedness to natural disasters. The main outputs consist of: a) recommendations for the urban planning of the four urban locations, aiming at minimizing the vulnerabilities identified; b) recommendations concerning the infrastructure assets and the physical investments that will be required to protect or upgrade the urban assets and systems in order to adapt to climate change impact and natural disaster risks; c) recommendations concerning the institutional preparedness and emergency plans in view of the climate change impacts and disaster risks; recommendations concerning the public information, education and communication campaigns to be carried out at local level; and d) an economic valuation of the implementation of the recommended adaptation actions against the costs of the impacts of climate change and natural disasters, if unchecked.

3. Disseminating the study results and engaging stakeholders in related decision-making: through: a) interaction with the national and local counterparts that have the responsibility for the management and development of the four urban locations; b) taking part in national and regional dissemination events organized by said counterparts, by the World Bank, with the collaboration of relevant agencies.

2. Content of the Present Report

The present report is aimed at summarizing the essential outcomes of the study in all of its phases, and draws the lessons learned from the process of carrying out the study and interacting with the local and national counterparts.

Following the introduction (Chapter 1), the presentation of the methodological approach applied (Chapter 2) enables to tackle the scope of work, methodological difficulties and limitations of the present study. Then, the main results of the analysis of risks and vulnerabilities of the four sites are analysed by risk category, on a comparative basis (Chapter 3). The way these risks and vulnerabilities are addressed within structured and integrated action plans is then presented (Chapter 4), with an emphasis on priorities and conditions of implementation. The current roles, mandates and capacity of the sector institutions and what performance improvements would be required are then presented (Chapter 5). The results of the economic valuation follow, as they apply to both phases of the study, highlighting the most cost effective actions (Chapter 6). Finally, the report concludes on the way the interaction with national and local stakeholders took place during the study, as well as on the formal workshops and consultations held (Chapter 7).

This Final Report draws from and refers to the detailed reports issued for each of the four urban sites studied, and while it provides a comprehensive summary of the study and of its methodology and key results, it does not substitute for the Phase 1 (Urban Risk Assessment) and Phase 2 (Adaptation and Resilience Action Plans) reports, which contain all of the technical findings and the recommendations. These reports are each provided with Executive Summaries in English, French and Arabic.

This report has been prepared by the consortium Egis BCEOM International / IAU-IDF / BRGM. The authors assume the full responsibility with regard to its contents.
3. **Project Stakeholders**

**World Bank Department and Unit in Charge:**
- Middle East and North Africa Region, Sustainable Development Department
- Urban and Social Development Unit, managed by Anna Bjerde and by Franck Bousquet

**Co-financiers:**
- Global Facility for Disaster Risk Reduction and Recovery (GFDRR)
- Norwegian Trust Fund for Private Sector and Infrastructure (NTF-PSI)
- Trust Fund for Environmentally and Socially Sustainable Development (TFESSD)

**Project team:**
- Anthony G. Bigio (Task Team Leader)
- Tim Carrington
- Stéphane Hallegatte
- Osama Hamad
- Salim Rouhana
- Asmita Tiwari

**Peer Reviewers:**
The team has benefited from the comments and advice of a number of peer reviewers in the course of the study, including Alex Bakalian, Henrike Brecht, Isabelle Forge, Jaafar Friaa, Francis Ghesiquière, Stuart Gill, Dan Hoornweg, Philippe Huc, Alex Kremer, Andrea Liverani, Michel Matera and Edward Tschan.

**Consultants:**
- Egis Bceom International in consortium with IAU-IDF and BRGM
  - Yves Ennesser (Egis BCEOM International)
  - Victor Said (IAU-IDF)
  - Monique Terrier (BRGM)
  - together with
    - Mireille Raymond, Dominique Cataliotti, Ion Bestelius, Jean-Michel Cathala, Franck Zangelmi, Guillaume Dulac, Michel Albientz, François Bertone, François Beauchain, Fabrizio Ferrucci for Egis BCEOM International; Eric Huybrechts for IAU-IDF; Terry Winter for BRGM.
with the contribution of Abdalah Mokssit and Fatima Driouech from Maroc Météo (Morocco), Mohsen and Nadra Tounsi from SIRUS (Tunisia), Azzeddine Motia from MORA Etude (Morocco).

**Partner of the World Bank for the study of Alexandria**

Arab Academy of Science, Technology and Maritime Transport

**Partner of the World Bank for studying land subsidence phenomena**

European Space Agency

**Partner of the World Bank for consultations and dissemination**

Marseille Center for Mediterranean Integration (CMI)

**Partners in Egypt**

Institutional Coordination

*National level*

Egyptian Environmental Affairs Agency (Coastal Zone Management Department)

*Alexandria*

Alexandria Governorate

Other Stakeholders

- Cabinet Information and Decision Support Center
- Coastal Research Institute
- Alexandria Holding Company for Drinking Water and Sanitation
- Ministry of Housing Utilities and Urban Development (General Organization for Physical Planning)
- Physical Planning Centre for Alexandria Region
- United Nations - International Strategy for Disaster Reduction
- RCDRR - Regional Center for Disaster Risk Reduction

**Partners in Tunisia**

Institutional Coordination

*National level*

Ministère du Développement et de la Coopération Internationale (Direction Générale des Infrastructures)

Ministère de l’Environnement et du Développement Durable (Direction Générale Environnement et Qualité de Vie)
**Tunis**

Municipalité de Tunis

Other Stakeholders

- Agence de Protection et d’Aménagement du Littoral
- Agence Urbaine du Grand Tunis
- Institut National de la Météorologie
- Ministère de l’Agriculture et des Ressources Hydrauliques (Direction Générale des Grands Travaux Hydrauliques, Direction Générale des Ressources en Eau)
- Office National de l’Assainissement
- Société Nationale d’Exploitation et de Distribution des Eaux

**Partners in Morocco**

Institutional Coordination

*National level*

Ministère des Affaires Economiques et Générales

*Bouregreg Valley*

Agence pour l’Aménagement de la Vallée du Bouregreg

*Casablanca*

Wilaya de la Région du Grand Casablanca

Other Stakeholders

- Agence du Bassin Hydraulique du Bouregreg et de la Chaouia
- Agence urbaine de Casablanca
- Direction de la Météorologie Nationale
- Direction des Ports et du Domaine Public Maritime
- Lyonnaise des Eaux de Casablanca
- Mairie de Casablanca
- Office National de l’Eau Potable
- Préfecture de Casablanca
1. Definition and Presentation of the Study Areas

There are several categories of criteria to define urban areas: administrative and political, geographical and physical, operational and dynamic, sociological and economic, etc. To define an urban area, the normal approach consists of crossing several criteria categories. The ideal option is to determine the study perimeters of the urban sites by making the following coincide: population catchment areas, the physical continuity of a conurbation, the geographical and topographical conditions and the administrative division.

The study’s prospective vision of urban development by the year 2030 relies on works that have already been carried out or that are being realized on the four sites. Most of these works practically target this deadline for measuring and planning development that is not only demographic, but also economic and urban. Spatially and physically translating this onto each site’s territory forms an essential data base for the study’s needs.

Given the above considerations, the extent of urban sites that has been selected for the study may be defined as follows:

- **Casablanca**: the metropolitan area of the sustainable development strategic plan’s perimeter, which has been spatially and statutorily conveyed by the urban development master plan (SDAU), recently validated. This perimeter includes the Prefectures of Greater Casablanca, Mohammedia and the Provinces of Nouaceur (Mohammed V Airport) and Mediouna, as well as the district of Mansouria. The present population of the study site is estimated to be 4.5 million inhabitants.

- **Bouregreg**: the study perimeter for the development of the Bouregreg valley and in particular, the perimeter of the urban development sequences. The Bouregreg valley is different from the other sites studied due to the fact that it is an urban area in progress, appointed to and managed by the “Agence pour l’Aménagement de la Vallée du Bouregreg” (Bouregreg Valley Development Agency).

- **Tunis**: the Tunis conurbation’s perimeter, such as it appears in the recently-approved development master plan. This perimeter will enable, as for Casablanca, the urban development vision to be settled by the year 2020-2030 (2030 for Casablanca, 2021 for Tunis). The present population is estimated to be 2.5 million inhabitants.

- **Alexandria**: in theory, the Region of Alexandria’s perimeter should be selected as defined within the preparation of the Urban Development Master Plan. As this document is only at the beginning of the elaboration phase, the perimeter of the current Master Plan which dates from 1996 was retained. The Region of Alexandria’s perimeter had an estimated population of 3.9 million inhabitants in 2006.

The maps shown on the next pages display the perimeter and main territorial features of the four sites under study.
Figure 1: Perimeter and land cover of the Greater Casablanca study site (source: AUG, IAURIF, Image Spot 2004)
Figure 2: The Bouregreg Valley Development Project (source: Agence pour l’Aménagement de la Vallée du Bouregreg, 2009)
Figure 3: Perimeter and land cover of the Greater Tunis study site (source: URBA CONSULT – URAM - BRAMMAH, 2009).
Figure 4: General Land Use Map of Greater Alexandria (source: AASTMT, 2010)
2. Methodology

2.1 Evaluation of Hazards, Vulnerabilities and Risks

The diversity of situations encountered (four urban sites in three different countries) and the uncertainties that weigh on the availability and precision of the data encouraged the Project team to adopt a flexible and adaptable methodological approach.

The study was indeed mainly based on data that is already locally available, or found in specialized publications, or available from international organizations. The study framework did not allow field measurement campaigns to be considered. The added value of this study is thus greatly based on the Project team’s expertise.

The Project team has however relied on certain number of technical and methodological tools:

- Interpretation of aerial photographs and satellite imagery,
- Digital elevation models,
- Data bases (particularly on seismic aspects),
- Geographical information systems (GIS),
- Specific calculation methods (for estimating natural risks and the associated damages),
- Modeling (climate change, urban floods, etc.),
- Pilot application to analyze and simulate subsidence phenomena using satellite imagery through the support of the European Space Agency (ESA).

Particular attention has been made to the climate change modeling for each urban site, a key point of the study. Entrusted to the “Direction de la Météorologie Nationale du Maroc” (National Meteorology Department of Morocco), this “downscaling” exercise has been carried out in close cooperation with the meteorological authorities of the two other countries. “Météo France” provided its expertise to review and analyze the final results of the climate change modeling.

The climate change forecasts for 2030 were included in the analyses and calculations which aim to specify the natural disaster and climate risks for this period. The methods ranged from simple extrapolation to modeling. For the Tunis urban area, the hydraulic models that were used to establish the flood risks were developed by applying new hypotheses relating to climate change and sea level rise. The application of new satellite imagery techniques (radar interferometry) for the Alexandria and Tunis sites, with the help of the ESA, enabled refining the analysis on both flooding and seismic issues.

All of the natural risks that were assessed, calculated or modeled were transferred onto map drawing bases at highly variable scales, depending on the precision and nature of the information. The scale of 1:25,000 was used for the main urban areas at stake (e.g. the “Basse Ville” of Tunis). These elements were analyzed and mapped using GIS, for the present situation and that of the year 2030, taking into account the expected climate change.

At the same time as the natural and climate risks analysis, the vulnerability components of the urban sites at present and for the year 2030 were determined. Generally, these vulnerabilities are made up of densely-populated areas, equipment and facilities that are essential to the functioning and security of the conurbation, and possibly some environmental components (suburban agriculture environment, natural environment, etc.). These elements were also analyzed and mapped using GIS to a scale reaching 1:25,000 for the most vulnerable sectors.
Crossing risks and vulnerabilities enabled the high-stake areas to be demarcated in reference with natural and climate risks.

This technical analysis was complemented by both the institutional analysis and the economic analysis. In the economic analysis and as part of an approach that is as broad as possible, direct and indirect costs of natural disasters and climate change were valuated, trying to include not only material damage, but also socioeconomic damage, among others (see Section 2.4). The institutional evaluation focused on the capability of local and national authorities to cope with natural and climate disasters in an urban context. It partly relied on case studies (see Section 2.3.).

2.2 Adaptation and Resilience Action Plans

The structural and methodological frame of the Phase 2 reports has been developed to ensure a necessary consistency and continuity with the Phase 1 assessments, with the aim of providing operational recommendations to decision makers.

As a result, the recommendations have been prepared using a sheet format, each sheet containing the relevant information for the definition and implementation of the recommendations: sphere of intervention (strategy), aim, time period (operational horizon), related risks, description, constraints / difficulties, uncertainties, concerned authorities and sectors, monitoring and evaluation means, cost, scheduling, mapping.

The recommendation sheets were presented by risk category: seismic risk, erosion / marine submersion risk (storm surge and tsunami), flood risk, drought / water scarcity risk, and multiple risks.

The sheets are complemented by an economic evaluation of the action plan and an institutional analysis. Following the definition of the main recommendations to reach the protection objectives against natural disasters and climate changes, and the provision of economic considerations, the most relevant and urgent recommendations were selected and classified according to identified stakes and expected benefits.

The purpose was to establish a progressive and realistic intervention programme of the actions to be carried out, taking into account the human and material means required for their implementation and the related costs.

Several intervention scenarios could be developed, considering the various assumptions, the priority level of the actions, their cost, and phasing possibilities, each scenario being a specific combination of recommendations. However, rather than selecting actions to define scenarios, It has been considered more relevant to propose a « programme », involving all actions organized according to a given schedule. The intervention programme was therefore structured in two successive phases:

- A short term programme (5 years), encompassing the first priority actions, which would constitute a quinquennial plan. Within this first plan, the most urgent measures – to be implemented during the first two years – can be distinguished from other recommendations.
- A medium term programme (10 to 15 years), for actions deemed less urgent and/or requiring financial investments likely to exceed the short term funding capabilities.
It is important to highlight at this point that adjusting the programme by shifting actions from one phase to the other is quite easy. The present programme therefore provides a great range of choices to the local authorities, according to their ambitions and capacities.

In terms of strategy, the action plan reflects a preference for robust actions, « no regret » actions, flexible actions (e.g. urban planning), and low cost actions (regulation, institutional measures …). Acquiring additional knowledge about some of the hazards, vulnerabilities and risks also remains a priority, as many of the recommendations require in-depth and detailed understanding before their effective implementation.

### Robust vs no regret decisions

Robust decisions/strategies/actions are based on decisions that are second best under certainty but are effective under uncertainty or, in other words, decisions that are sub-optimal under any specific climate scenario, but become optimal when a range of possible futures is considered.

No regret actions on the other hand are those that contribute to adaptation but that should be taken anyway, even without adaptation. Building a dam is a no regret adaptation action if it already makes sense today, without climate change…If climate change impacts are not to materialize, there would be no regrets concerning the cost of the dam.

#### 2.3 Institutional Analysis

A two-pronged approach has been used in order to perform the required tasks: Institutional Mapping over the Disaster Cycle Management (DCM); Case study analysis.

**Institutional Mapping over the DCM**

The evaluation included an assessment of the roles and activities of national and local institutions that are currently responsible for the urban planning, provision of urban infrastructure and services, and for disaster preparedness in the four urban locations.

The purposes of such assessment was to:

- a) establish the boundaries of their competencies, and identify any possible overlaps or gaps;
- b) gauge their responsiveness and capacity to integrate climate change considerations and natural disaster preparedness in the management of the urban locations under their purview.

The following matrix displays the methodological approach. This approach was supported by an investigation guide. The purpose was to reach an optimal trade-off between structuring / completion of the data on one hand, and flexibility / adaptability on the other hand.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Required data</th>
<th>Data processing</th>
<th>Method for data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify national and local institutions involved in natural disasters, urban planning and infrastructures</td>
<td>Laws, decrees, official publications and other administrative documents</td>
<td>Reading / synthesis</td>
<td>Internet research; Collection of documentation from the concerned institutions; Interviews with key stakeholders</td>
</tr>
<tr>
<td>Establish their respective mandate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The proposed task consisted, in each of the project area, in a kind of “who-is-doing-what-where” matrix. The important thing was to present this information in a way that is easily usable, i.e. for the recommendations of Phase 2. Depending on the collected data, the best format was proposed, taking into consideration a necessary consistency between the four urban sites.

This institutional mapping enabled to easily point out the gaps and overlapping in responsibilities regarding two orientations: space (who is involved at which territorial scale?) and thematic (who has the mandate for doing what?). For example, it is often the case that there are too few communications between the different actors involved in the DCM. In this regard, the “preparedness” phase is often quite isolated, especially from prevention. Another line along which the consultant insisted is the split of responsibilities between national and local level because it proves to be also crucial to have a well thought balance here.

This task was also aimed to review (and identify any revisions required) current planning and enforcement tools for urban growth management and disaster preparedness – such as development control regulations, zoning, building codes, Disaster Preparedness Action Plan. This exercise helped in preparing the Adaptation and Resilience Action Plans.

**Case study analysis**

Although the institutional mapping proposed above proved to be a powerful tool of analysis, the consultant considered it was not enough to find out all improvement required in the institutional field as far as DCM is concerned. Indeed, there are often discrepancies between theoretical and legal perimeter of authority and the reality. This is mostly the case if the budget allocated is not consistent with the responsibilities provided to a given entity.

This is where it can be very useful to perform a case study analysis upon events such as natural disasters. It shows the consistency between official attribution and what has actually been done. Together with the stakeholders of the project, the consultant focused on one event per area as to challenge the findings of the institutional mapping, and see if any good lessons are worth to be learnt.

### 2.4 Economic Valuation

The economic methodology followed a two pronged approach:

- identification of a ‘reference’ scenario, also known as the Business as Usual (BaU), for which the costs associated with the natural disasters covered by the study are evaluated (Phase 1);
- evaluation of the costs of adaptation measures proposed and of the proportion of damage those actions could prevent in relation to the BaU scenario, in order to provide elements for appreciation of their economic effectiveness (Phase 2);
This methodology, derived from the Cost-Benefit Analysis (CBA) method, is intended to provide decision-makers with the economic component of the terms for complex development choices. To achieve this, the BaU scenario must be a credible reflection of future urbanisation as currently foreseen (vulnerability) as well as magnitude of hazards, possibly enhanced by a changing climate. While the exercise is, by its nature, prospective and uncertain, it is nonetheless necessary: failure to take account of the BaU scenario underlying the changes in vulnerability and hazard could jeopardize quality and relevance of the analysis.

From the quantitative point of view, the CBA is generally based on the net present value (NPV) or cost-benefit ratio. In finance, this means comparing the discounted gains and losses associated, in general, with a given investment. The parallel here is to consider as ‘gains’ the damage avoided in the BaU situation and for which additional investment is proposed and as ‘losses’, the cost of implementation of adaptation measures.

Even though the concept may appear simple, its application requires reaching a firm agreement on the BaU scenario and on the perimeters of each the associated costs and benefits. The BaU scenarios were therefore the cities of Tunis, Casablanca and the Bouregreg valley and Alexandria in 2030 in a situation of climate change. All assumptions and calculations methods are provided in greater details in the Phase 1 and Phase 2 reports but the main projected drivers of change in vulnerability considered are: real state (intensively and extensively), demography and economic growth, as well as already decided but not yet implemented relevant infrastructures such as drainage systems. From this point in the future, profile was set throughout the overall horizon considered.

Throughout the many calculations involved, a “conservatism principle” has been used, giving precedence to under-estimation of economic damage rather than the converse. In fact the Phase 1 costs form the basis of potential gains in the subsequent analysis (Phase 2). Now, methods for assistance in making decisions about investment, whether structural or otherwise, were based on over-estimation of expenditure and under-estimation of gains, in order to ensure that the deduced return is not wildly optimistic. Similarly, uncertainties were numerous. Also, rather than sometimes choosing a value from the upper part of a bracket then one from the lower part, it was more advisable to retain the same tendency so as to always know in which direction the error is ‘leaning’.

The total cost of a given event was set as the sum of its direct and indirect costs. The calculation of cost was based on the concept of annual average cost (AAC), to allow for frequencies and intensities of hazard events. For a given type of disaster, the integral of the costs weighted by their respective probabilities gave the AAC, and corresponded to a mathematical expectation.

Direct cost means the evaluation of direct damage. Direct damage is material damage arising directly from an event, and that is tangibly verifiable immediately after the event. Evaluation of direct economic damage is largely based on working with a GIS relating hazard events and vulnerability. The damage calculated therefore relies on the spatial extent inherent to the different events and to the vector of vulnerabilities of each type of urban typology affected. There are different methods for assessing damage. The study proposes an analytical approach with production functions, called here damage functions. Their construction is based on vulnerability functions specific to each hazard (for earthquakes for example it was derived from the EMS 98 standard). It is distinct from the so-called revealed methods, including hedonic and contingent methods.

The main driving force for evaluating indirect costs is the human factor. We have opted to include the latter by using population density. Indirect costs associate a loss expressed as man-
days in the areas affected as a function of the intensity of an event, as well as a loss of the same nature but lower in unit terms over a wider area (once again dependent upon the event), to take account of the causal link between an affected place and the impact on its more or less remote environment.

The evolution over time of these costs and benefits is a difficult question (mainly because of the high sensitivity on the results with important horizons), discussed in Phase 2. Main features are the following:

- The horizon was finally set at 40 years, but calculations included adjustments for investments with greater horizons;

- The discounting rate profile was adapted from state of the art techniques (probabilistic and uncertainty analysis derived from the Ramsey Keynes model); the rate is taken constant for 20 years then declining progressively; a sensitivity analysis was performed on key discounting driving factor;

- Profiling of cost and benefits is also discussed, and mainly backed along the local economic growth, with progressive impact of climate change as figured out by downsizing outputs.

Finally, a calculation of the NPV and cost benefit ratio (B/C) on the whole set of measures per site was performed and adaptation measures were ranked along decreasing order of efficiency, measured by B/C. It is important to recall that by construction, the results rely upon the BaU, reflecting the urban vulnerability, including the already approved adaptation measures. The results should not be interpreted out of this context. For example, a limited ratio B/C of a given measure can mean that the hazard is not that significant or on the contrary that it is but has already been (or is about to be) taken care of efficiently. In that sense, the methodology was first built to contribute to local decision making rather than a comparison between adaptation options.

### 2.5 Interaction with Stakeholders and Partners

The Consultant (consortium formed by Egis Bceom International, IAU-IDF and BRGM) has worked in close collaboration with the various national and local stakeholders, whereas the World Bank team, in charge of the study, has maintained institutional relations and has facilitated regional exchanges. For each country and locality, the World Bank had the support of the main institutional and technical partners.

We must state that this study would not have been made possible without the support of a certain number of local, national and even international technical agencies, identified by the World Bank, and which possess information that they made available to the Project team. These organizations, with highly-qualified personnel, have also been requested to give their opinions on the study’s results, within the framework of the consultation initiatives (Internet website, presentation meetings).

For Alexandria, the Arab Academy for Science, Technology and Maritime Transport (AASTMT), a regional research and learning centre registered with the Arab League, wished to heavily invest itself in the project. It offered its active contribution to the World Bank with its own funds. This technical and methodological contribution was in addition to that of the Consultant, and was the subject of an agreement signed between the Bank and the Academy on 20 July 2009.
The territorial and innovative character of the study also interested the European Space Agency, which offered to introduce an application using satellite imagery by means of the Earth Observation Market Development (EOMD) program, directed by the European Space Research Institute. To bring this project to fruition, the Consultant composed a “Project team”, comprising specialists from the main areas of expertise required for this study (climate change, natural risks, urban planning, infrastructure, geographical information system, and economic and institutional analysis). These specialists are mainly “in-house” experts from the three companies forming the consortium. It was, however, considered to be advantageous to strengthen the Project team with regional experts possessing specific (climate modeling, institutional analysis, etc.) or transversal (natural risks) skills; they completed the pool of expertise and benefits has been taken from their knowledge of the field. Each expert of the Project team represented a “focal point” of the study for a given subject. In particular, this organization enabled dialogue to be facilitated and information exchanges with the AASTMT for Alexandria to be made easier.

More than nine months of missions in the concerned countries have been carried out so that the experts could acquire precise knowledge of the issues and exchange information with the local institutional and technical partners. Moreover, these exchanges have culminated by means of several national and regional seminars, which gathered all the stakeholders at the end of each phase of the study. A dedicated website was also set up to ease data exchange and information dissemination.

Interactions between the project team and the main local technical agencies are presented hereinafter.
PRINCIPLES FOR COLLABORATING WITH THE LOCAL TECHNICAL AGENCIES

LOCAL TECHNICAL AGENCIES

MOROCCO
- Bouregreg and Chaouia Hydraulic Basin Agency
- Lyonnaise des eaux de Casablanca
- Casablanca Urban Agency
- Others

TUNISIA
- Coastal Protection and Planning Agency
- Department of Urban Hydraulics
- National Sanitation Utility
- National Meteorology Institute
- Department of Land Development
- Others

EGYPT
- International Strategy for Disaster Reduction
- Coastal Research Institute
- General Organization for Physical Planning (and Physical Planning Center for the Region of Alexandria)
- Others (EEAA, Alexandria Governorate …)

AREAS OF WORK
- Hydrography, hydrology, hydrogeology, water resources
- Topography, hydraulics
- Land cover, housing, equipment, facilities, environment
- Oceanography, geology, seismology
- Topography, oceanography
- Hydrography, hydrology, hydraulics
- Topography, hydraulics
- Climatology, seismology
- Land cover, housing, equipment, facilities, environment
- Water resources, geology, hydrogeology
- Seismology
- Oceanography
- Climatography, topography, hydrography, hydrology, geology, hydrogeology, hydraulics, water resources

PARTIES WITHIN THE PROJECT TEAM
- Egis BCEOM International (EBI)
- IAU-IDF
- EBI, BRGM
- Maroc Météo BRGM
- IAU-IDF
- EBI, BRGM
- BRGM
- EBI
- IAU-IDF
- Maroc Météo, EBI, BRGM

CONSULTATION

VALIDATION
3. Limitations and Constraints

The present section is important to fully understand the scope and significance of the study results.

Regarding the evaluation of the natural disasters and climate risks in the present situation, the main limitations of the methodological approach are the following:

- Availability of map information in vectorized form (i.e. localizable in x/y coordinates).
- Heterogeneity and availability of topographic data.
- Availability of aerial photographs.
- Hydrologic analysis mainly based on climatologic data.
- Lack of detailed hydraulic studies for the Alexandria urban area.

The evaluation of natural disasters and climate risk evaluation for the year 2030 has globally shown the same difficulties that were encountered for the present situation, to which were added uncertainties regarding climate change:

- Forecasts carried out by the IPCC on climate change rely on a certain number of postulates in terms of demographic and economic development, and fossil fuel energy use. The uncertainties which result from the use of global climate change models are maintained, or even enhanced, during the downscaling of these global models. The analysis can be refined, but uncertainties cannot be reduced. Moreover, the results are sometimes very different from one model to another. Within the framework of this study, the biases and uncertainties were nevertheless partially compensated by taking into account three IPCC scenarios relatively contrasted (scenarios B1, A1B and A2), and downscaling using three different models. The uncertainties were not suppressed but they were at least made apparent by the diversity of the scenarios and models used. It must be remembered that the modeling of climate change is probabilistic: this involves establishing for each urban site a probable climate change scenario for the year 2030. This vision of the climate’s future, based on relatively preliminary hypotheses, sets aside numerous unknown elements, in particular the natural variability of the climate and economic “accidents”. As part of this study, we have tried to highlight the variability of the considered climate forecasts for 2030, and selected the most conservative hypotheses – in other words, the most pessimistic (in coherence with the safety principle) – to create the scenario whose impacts was tested in the four urban sites. In the next years, as new findings may become available, periodical revisiting the climate modeling is highly recommended.

- The analysis of subsidence phenomena was carried out by interpolating noticed changes, without prejudging possible variations of these phenomena for the next twenty years.

- As for the climatologic analysis, the seismic risk analysis for the year 2030 was deterministic, i.e. based on factual scenarios.

- Apart from the sea level rise phenomenon, the change of coastal erosion mechanisms mainly depends on known coastal development projects and river dam projects.

- The impact of climate change on water resources was directly extrapolated from forecasts in terms of rainfall and temperatures obtained by downscaling. The most
difficult was evaluating the change of drought periods which are already highly unpredictable nowadays.

- The uncertainties on IPCC forecasts are even more important as the modeled events are rare, and thus they are uncertain. The forecasts are therefore relatively reliable concerning average annual rainfall, but are a lot less so concerning exceptional rainfall. The hydraulic analysis relied on the impact assessment of climate change on floods and flooding conditions. Consequently, the hypotheses used to assess or model the flood risks were marred with high uncertainties.

Identification of urban vulnerabilities encountered three main levels of difficulty:

- Capability of establishing a microzonation of the high-density housing sectors and informal housing areas.
- Availability of precise information on equipment and facilities that are sensitive to natural and climate change risks.
- For the year 2030 is added the problem of uncertainties on the demographic and urban growth forecasts.

The economic valuation, i.e. evaluating the socio-economic costs of climate change and natural disasters, is a complex process. The timeframe and manpower available under this study did not allow very accurate data collection and data processing. A quantification exercise has however been performed but it should be kept in mind that the deliverables should only be used for determining main driving forces of vulnerability and providing guidance to decision-makers as far as strategic land management options are concerned. It should not be the purpose of any kind of accurate budget programming exercise.

The institutional analysis proposed within the framework of this study relies on a two-leveled approach: an institutional map of the Disaster Management Cycle and an analysis of case studies. The first level does not, in theory, involve any major difficulties. Given the complexity and the multiplicity of the stakeholders involved in the management of natural risks, the first task has been limited to a first approach aiming to identify the main lacks, insufficiencies and discrepancies. Failing relevant case studies available in the urban areas under study, the study has been conducted, in each country, on the event for which the most complete and objective information was available.

The action plans limitations are directly related to the knowledge of risks and vulnerabilities in the study areas and to the global and strategic method of addressing these issues within the framework of the present study, as above mentioned. Most of the recommendations call for the implementation of additional studies and surveys, likely to remove part of the uncertainties related to natural disasters and vulnerabilities. In this context, the proposed prevention or protection investments cannot be precisely defined. It is especially difficult to estimate investment costs, so most of the costs provided in the action sheets are given as an indication, or as an example. Therefore, the action plans do not seek either to be comprehensive or of immediate implementation, but is rather aimed at providing the local authorities with the technical and economical background enabling them to incorporate the recommendations in the plans and programs currently being prepared or to be implemented.
Importance of data quality and availability

Tunis is the urban area where it has been possible to reach the highest level of detail, thanks to data availability and possibility of modeling flood issues, based on specific hydraulic models developed by Egis BCEOM International and SIRUS when working on the Tunis flood master plan in 2005. The availability of a precise Digital Elevation Model (DEM) and a thorough analysis of the “urban fabric” by construction category, also contributed to the level of detail of the final outputs.

Despite the existence of flood modeling tools for the Casablanca urban area and the Bouregreg Valley, the Casablanca sewage concessionary company and the Bouregreg project owner did not make it possible. Flooding assessments in both areas were therefore performed on a semi-quantitative way, based on previous hydraulic studies, the results of which being interpolated with new hydrological assumptions and taking sea level rise into account. The availability of precise DEM allowed simulating marine submersion impacts. The abundant set of data provided by the Casablanca SDAU and the Bouregreg Special Development Plan also enabled precise determination of urban vulnerabilities.

As to the Alexandria urban area, since hydraulic studies, precise DEM, or reliable future urban development scenarios were not available, the risk approach was mainly qualitative, based on the expertise of the Consultant.

As a result, even if the present report allows some comparative analysis between the four urban sites, it must be remembered that the level of detail was not the same depending on the site, and thus the assessments do not show the same reliability. In other words, reliability on natural disaster and climate change risk assessment is considered high for Tunis, medium for Casablanca and the Bouregreg Valley, and low for Alexandria. This statement calls for caution in interpreting all attempt of direct comparison of the four sites regarding natural disasters and climate change impacts. The main lesson drawn from this study is above all that further studies are required, especially in the case of the Alexandria site.
Chapter 3 – Urban Risk Assessments

This chapter presents the main results of the first phase of the study devoted to the evaluation of risks and vulnerabilities for the present situation and horizon 2030. The presentation is structured by risk category and proposes a crossed analysis of hazards and vulnerabilities of the four urban areas under study.

1. Ground Instability / Seismicity

1.1 Presentation of the Hazards

Studying the geological, geotechnical, and topographical context of the study regions and study areas leads to assess ground instability, subsidence phenomenon, and contribute to assess the risk of seismic hazards.

The tectonic framework differs between the four locations, even if these sites belong to the Mediterranean domain, which is the convergence zone between Europe and Africa. Tunis is located at the edge of a zone of active tectonic convergence between European and African plates, and Alexandria is close to two active fault zones in Egypt (eastern Mediterranean Cairo Faiyum and Suez-Cairo Alexandria faults). Contrarily, the Casablanca and Bouregreg Valley sites are located far away from the active convergence zone, on the coastal area of the Moroccan Meseta, separated from the central Meseta area by a currently inactive fault. The following map displays the resulting seismic hazard levels in the Mediterranean basin.

Figure 5: Seismic hazard map of the Mediterranean region (Source: SESAME project)
The geological contexts of the studied localities present some similarities. The study areas of the four sites are located mainly on quaternary formations, on alluvial plains, “wadis” and watersheds (“sebkhas”), and present some sedimentary deposits and sandy soils. It results in a poor geotechnical quality of the soils, which favours soil instability resulting in liquefaction, settling, or subsidence phenomena. Subsidence effects are especially strong in Tunis (up to 3 cm/year in the Lower City), while Casablanca is the less affected site by soil instability.

Figure 6 : Maps of the main areas of ground motion in Tunis, detected through satellite imagery (Source: RTE, 2010)

The topography of the studied locations is rather varied. Tunis and the Bouregreg Valley present areas with steep slopes, characterized in general as being over 5%. These areas are located in the north-west and the south-east of the study area for Tunis, and for the Bouregreg (with slopes up to 50%) at the edge of the plateau overlooking the alluvial plain, and on the slopes over the plain. Casablanca and Alexandria present very localised slopes (littoral road, river banks, or small hills), most of the study areas being a plain with small hills and gentle slopes. Steep slopes can lead to ground instability resulting in landslides and rock fall.

Ground instability phenomena can be a worsening factor for seismic risk. Ground stability and seismic hazards are independent of climate change; consequently, the hazards described in the current situation will not be significantly different in the 2030 situation.
1.2 Evaluation of the Vulnerabilities

Urban components vulnerable to earthquakes and ground instability hazards have been approximated as following the same methodology as for the other hazards. The nature of the "urban fabric" (i.e. type and structure of buildings) is the main criteria taken into consideration.

In the current situation, dense residential districts built with poor quality material are the most sensitive: Tunis’ “Basse ville”, Casablanca’s medina and Kasbah, or Oudayas Kasbah and Rabat and Salé medinas (N.B.: out of the study area), as well as informal urban settlements in Tunis, Casablanca, or Alexandria. In the Bouregreg Valley, the douars spread out in the valley, poor quality rural housing, are the most sensitive components.

The four locations, and thus their sensitive urban components, are situated mainly on poor geotechnical quality soils, which make them vulnerable to ground instability hazards. In Tunis, the Basse Ville, and the Rades Port (to a lower extent), are the areas where subsidence levels are mostly over 2.5mm/year, when the northern border of Lake Maryut, and the Southern part of the city between Garb district and Abu Quir are the most affected in Alexandria.

In 2030, the sensitive urban components are the same for Tunis, Casablanca, and Alexandria, with a reduction of the vulnerable surface in Tunis and Casablanca, with a projected reduction of urban density, clearance of insecure housing and slum areas, and quality improvement of construction materials. In the Bouregreg Valley, the valley’s urban planning programme, based on high standing buildings, is assessed as not being very sensitive to this risk. In addition, the valley urban development plan keeps all sectors likely to be affected by erosion risk, gullyng or landslide risk, as natural area, forested area or protected nature reserve. In these areas no construction will be allowed and protection measures will be implemented.

1.3 Risk Assessment / Comparative Analysis for the 4 Locations

A probabilistic assessment of the earthquake risk carried out on the different study locations gives the earthquake intensity, expressed in MSK (Medvedev-Sponheuer-Karnik scale of seismic intensity), for a given return period.

The poor geotechnical quality of the soils in the four locations is considered as an aggravating factor (“site effect”) in case of a seismic event. In particular, the areas of high subsidence (>2.5mm/year) are considered as presenting an increased seismic risk.

For a 50 years return period, the intensity of the seismic event on the MSK scale is the following:

<table>
<thead>
<tr>
<th>Intensity (MSK)</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>In areas affected by site effect (MSK)</td>
<td>VI</td>
<td>IV to IV-V</td>
<td>IV to IV-V</td>
<td>VI</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>NA</td>
<td>V to V-VI</td>
<td>VI-VII</td>
</tr>
</tbody>
</table>

The type of damage that would occur is structural damage to buildings and collapses. According to the following USGS table of correspondence, it is considered that – for this return period – moderate damage would occur in Tunis and Alexandria, very little to little damage in the Bouregreg Valley, and no or very little damage in Casablanca.
The seismic event would in general be of the same intensity in the current situation and the 2030, but with a greater exposure to risk in areas to be urbanized by 2030 and that will be located on soils vulnerable to ground instability, in particular in areas of high subsidence. However, it is assumed that the urbanization project will take the risks into account.

What precedes leads to the following assessment of the risk level for seismicity/ground instability, in the current situation, and in 2030, for the 4 locations:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation</td>
<td>Medium</td>
<td>Very Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2030</td>
<td>High</td>
<td>Very Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

2. Tsunami / Marine Submersion

2.1 Presentation of the Hazards

Marine submersion can be defined as the temporary flooding of coastal region by sea during severe meteorological (strong depressions and sea wind) and tidal conditions causing storm surges. The submersions may occur due to:

- The rupture or destruction of a sand dune string,
- The overflowing and rupture of coastal protection works sideways to the sea
- Exceptional overflowing by « sea billows ».
- The very high waves (tsunamis) provoked by under water land slides or earthquakes.

The variations of the water level at the origin of marine submersion are a combination of several phenomena: astronomical tide, meteorological factors (wind, atmospheric pressure), hydrodynamic factors (set-up, surf-beat, etc.).

Based on a critical analysis of the IPCC projections and the latest references in the literature on the subject, a global rise in sea level of 20 cm by 2030 is assumed for this study. It should be pointed out that this is a high projection (see Figure 8), and that the trends in sea level rise currently measured on the different coastal areas are much lower. High projections will however help in simulating and planning for worse scenario that can result from Climate Change.
Figure 8: Recent projections of seal level rise

The total storm surge considered in the case of an exceptional combination of events (50 years return period) is therefore as follows:

<table>
<thead>
<tr>
<th></th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme level in the current situation</td>
<td>+1.13m NGT(^1)</td>
<td>+2.77m NGM(^2)</td>
<td>+2.65m NGM</td>
<td>+1.57m LAT(^3)</td>
</tr>
<tr>
<td>Extreme level 2030</td>
<td>+1.34m NGT</td>
<td>+2.97m NGM</td>
<td>+2.85m NGM</td>
<td>+1.77m LAT(^3)</td>
</tr>
</tbody>
</table>

A tsunami is a very large ocean or sea-wave triggered by various large-scale disturbances of the ocean floor such as submarine earthquakes, volcanic activities or landslides. The seismic structures likely to create a tsunami in the four studied locations are different, but located mainly on the Euro-African plates convergence zone: the Hellenic arc for Alexandria, the offshore limit of the Tell and Atlas and the Hellenic Arc for Tunis, and the Europe-African plate limit in Cadiz Gulf for the West-Moroccan coast. None of studied data catalogues show the occurrence of a tsunami in the Tunis area. **The most damaging tsunami in the Casablanca-Bouregreg areas occurred in 1755**, with a wave height of around 2m; another significant 1969 tsunami occurred in 1969 with 0.9m wave (see Figure 9). The two most destroying known tsunamis for Alexandria were dated respectively from the years 365 and 1303, with a wave height of respectively 1m and 2.9m.

\(^1\) NGT = Nivellement général de la Tunisie  
\(^2\) NGM = Nivellement Général du Maroc  
\(^3\) LAT = Lowest Astronomical Tide
Figure 9: Seisms of known epicentres and responsible for tsunamis along the Moroccan coast (Source: Kaaboulen et al., 2009)

For characterising the hazard, the following can be assessed for a 50 years return period:

<table>
<thead>
<tr>
<th></th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intensity</strong></td>
<td>simulations: 0.25 – 0.4m wave</td>
<td>1969 type, wave around 1m</td>
<td>Wave around 1m</td>
<td>365/1303 type, wave around 1-3m</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>negligible</td>
<td>20%</td>
<td>20%</td>
<td>6%</td>
</tr>
</tbody>
</table>

The hazard in 2030 is remaining the same as in the current situation.

The magnitude of a marine submersion by storm surge or tsunami does not depend only on the storm surge level, but also on the coastal morphology, which minimizes or accentuates phenomena. As a result, the marine submersion hazard was classified as low, medium or high along the coastline of the four studied areas. In particular, in the current situation the hazard is high in Tunis at Landalous Kaat, Raoued and La Goulette coast, on Rades, Hammam Lif shores. The hazard is high on small beach sections in Casablanca and Mohammedia, and on Rabat’s beach. In Alexandria, it is high in Dekhiela and Western harbors, and east of El Montaza Palace to Abu Quir.

2.2 Evaluation of the Vulnerabilities

The areas vulnerable to marine submersion in the four studied locations are the areas presenting socio-economic or patrimonial issues or value, located on the littoral (cliffs, beaches), and low lying areas along the coast line (urbanized areas, wetlands, estuaries).

In the current situation the vulnerable areas submerged in Tunis would be part of the urbanised and industrial areas in Basse Ville, Radès, Ezzahra and Hammam Lif Ouest; Tunis’ North Lake’s and South Lake’s shores, the Mejerdia estuary, and the Sebkhas are also potentially vulnerable. In Casablanca, the dense urban areas along the seafront, the far eastern coastline, and the Mohammedia refinery are particularly vulnerable areas. In the Bouregreg...
area, the most vulnerable component is the Bouregreg river mouth, with the Salé and Rabat sandy beaches. In Alexandria, the vulnerable areas are the preserved natural shore and the densely urbanized coastline. The Abu Quir seawall, built in 1780 to protect the low-lying land behind it from sea flooding for agriculture purposes, and reinforced many times, may however be damaged during a major tsunami or coastal storm.

In 2030, the vulnerable components and areas will remain the same. An increasing urbanization along the seafronts and some major urban projects will increase the vulnerability of certain areas: urbanization along the seafront and along the lake shores in Tunis, several coastal urbanization projects in Casablanca, urbanization at the top of the beach and new residential districts built at the bottom of the valley for the Bouregreg, and increased seafront urbanization for Alexandria.

2.3 Risk Assessment / Comparative Analysis for the 4 Locations

The risk for marine submersion is the combination of the hazard which affects a particular area with the sensitivity/vulnerability of a particular spot.

Tunis presents areas of medium risk in the current situation as well as in 2030, with longer linear for 2030. The concerned areas are between Kalaat Landalous and Raoued beach, Gammarth and south Marsa, and South Cathage and La Goulette.

Casablanca only presents high and medium risk areas in the current situation as well as in 2030, in particular the high risk areas are between Casablanca and Mohammedia, Mohamma and Sablettes beach, the Corniche and Aïn Diab, and between David and Dahomey beaches. The Bouregreg study area present a high risk for Rabat beach and medium for Salé beach in the current situation, but the risk goes down to medium on the whole linear in 2030 with the marine protection works planned at the mouth of the Bouregreg.

Alexandria presents high level risk between Dekhiela harbour and Western harbour, and at Abu Quir in the current situation as well as in 2030, and the Abu Quir sea wall might see an increased risk rising if its sea wall is not maintained properly, leading to submersion of residential areas.

In 2030, taking into account the planned protection works, the areas concerned by marine submersion risk will change, in general for an increased value. One can compare the areas likely to be submerged between 2010 and 2030:

<table>
<thead>
<tr>
<th></th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area submerged 2010 (ha)</td>
<td>4500</td>
<td>1200</td>
<td>860</td>
<td>Not calculated</td>
</tr>
<tr>
<td>Area submerged 2030 (ha)</td>
<td>5500</td>
<td>1350</td>
<td>1000</td>
<td>Not calculated</td>
</tr>
</tbody>
</table>

The types of damage that can occur from a marine submersion event are structural damages to the building located in the front, and submersion of low areas. The following table can be drawn from what precedes:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>2030</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Figure 10
Marine submersion risks in Mohammedia

LEGEND
Submersion for a 50-year storm surge

- Present situation: 2.77m NGM
- 2030: 3m NGM

500 Meters

Map created by: egisbecom, IAU, brgm
3. Coastal Erosion

3.1 Presentation of the Hazards

The erosion hazard is often defined as a strip of “erodible” land over a period of 100 years. The delimitation of this area therefore is based on the calculation of the annual average erosion level observed during diagnostic studies. Its changing pattern needs to be extrapolated on long term considering the annual average rate calculated during the period studied as invariant.

Erosion is caused by different factors:

- natural erosion due to long term physical trends (ex: cliff erosion),
- erosion due to a deficit of sediment transport, often due to the construction of dams on rivers, or other coastal works which prevent the natural sediment refill
- erosion due to the presence of hard structures on the beaches: if the beach is not sufficiently wide for withstanding the swell or if the upper side of the beach is contained by "hard" structures (residential buildings, walls running lengthways), the erosion of the beach profile is heightened,
- erosion due to sea level rise

The combination of these driving forces, taking local coastal characteristics into account, leads to some differences between the sites under study.

In Alexandria, coastal erosion hazard is medium to high between the Dekhiela harbor and the Western port of Alexandria, as well as at the El Montazah, El Maamoura and Abu Quir beaches due to the absence of coastal protection devices along these beaches of low width and slope. Beaches of Alexandria, from Mandara to El Silcila, are experiencing chronic long-term erosion of ~20 cm/yr. More than 50 % of the sandy beaches between El Montaza and El Silcila, 14.5 km long, have significantly disappeared following seaward widening of the Corniche highway constructed between 1998 and 2002, creating “sediment starved” coastal cells.

In Casablanca, erosion hazard is high on a small linear of beaches in Anfa, Mannesman, Monika and Sablettes in Mohammedia. It is medium on most of the coastline, and in particular between the Corniche and Dar Bouazza edge. It is low along the Mansouriah cliffs.

At the mouth of the Bouregreg valley, the hazard is high for the Rabat beach, due to its limited width and former erosion process, and medium for the Salé beach, wider and showing a more marked slope.

In Tunis, the study area coastline, between the mouth of the Mejerda wadi to the north and Slimène beach to the south, consists of, more or less extensive, sandy beaches separated by rocky points. The coast is ever-changing with an overall trend towards erosion. This imbalance is due mainly to a sediment deficit caused by trapping of sedimentary particles at the dams on various wadis and, in particular, the Mejerda wadi to the north; to fixation or disappearance of the dunes bordered by seaside resort urban development; and to blocking of transport of sedimentary material by port facilities. The coast has generally been receding for half a century but this has never exceeded 1 m/yr on average and has been delayed, and sometimes stopped, by the alongshore protection constructed and by the presence of rocky
flats. However, the coastline can recede by as much as 10 m/yr locally (e.g. at the former Medjerda mouth, see Figure below).

**Figure 11 : Evolution of the shoreline at the former Medjerda mouth since 1982**

For the **2030 horizon**, the same 20 cm SLR assumption as for the submersion hazard is considered. In spite of numerous projects for coastal protection (especially in Tunis), the rise in sea level will reactivate or amplify the process of coastal erosion, and therefore receding of the coastline (see Figure 12). In the urbanised areas, already protected by structures or along which protective works are projected (widening of beach by massive replenishment with sand then periodic maintenance, breakwaters, groins), retreat will be slower but nonetheless inexorable.
In case of storms combined with high water levels, beach head works in urbanised areas risk severe damage, as the width of the beach is not sufficient to dampen the effects of the swell as too close to the high tide line. The sandy beaches still in a natural state face a risk of retreating by an average of 10 to 15m by the year 2030. However, they should be able to partially reconstitute in periods of fine weather, and almost entirely when the beach head consists of dunes.

Only at the mouth of the Bouregreg Valley, the breakwater construction project should be in a position to reduce the negative impact of sea level rise associated with strong swells. Beach erosion will continue, however, at a slower pace.

3.2 Evaluation of the Vulnerabilities

The areas vulnerable to coastal erosion in the four studied locations are the same as for the submersion risk (please refer to the above section 2.2.).

3.3 Risk Assessment / Comparative Analysis for the 4 Locations

By 2030, in Tunis, all of the coast between Kalaat Landalous and the Touring Club on the Raoued beach will be severely eroded whereas in the present situation the coast between Hessiène wadi and the southern part of the widest area of the Raoued beach – which still has a line of dunes at the beach head – is at low risk. There will be also major changes of the coast between Ezzhara and Hammam Plage (inclusive), which will be at high risk of erosion whereas at present the Ezzahara and Hammam Beach stretch of coast is classed as having a medium risk of erosion.

In Casablanca, the map of coastal risks, established by comparing the coastline's socioeconomic and environmental stakes/vulnerabilities and the submersion and erosion hazard, shows a coastal erosion risk essentially located between the far eastern end of Casablanca and the Mohammed refinery, on an area with approx. 10 km of beaches. The construction of a new breakwater at the mouth of the Bouregreg Valley will reduce erosion risks.

In Alexandria, the situation will mainly worsen along the semi-natural western beaches of Borg Al Arab due to urban expansion (see Figure 13).
Figure 13: Evolution of the coastal erosion by 2030 along the Greater Alexandria shoreline (Source: Egis BCEOM International, 2010)

Taking into account the planned protection works, the coastal stretches concerned by erosion risk will change, according to the following values:

<table>
<thead>
<tr>
<th></th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>High erosion risk in 2010 (km)</td>
<td>16</td>
<td>42</td>
<td>2</td>
<td>Not calculated</td>
</tr>
<tr>
<td>High erosion risk in 2030 (km)</td>
<td>27</td>
<td>42</td>
<td>0</td>
<td>Not calculated</td>
</tr>
</tbody>
</table>

The following table can be drawn from what precedes:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>2030</td>
<td>Very High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
4. Flooding

4.1 Presentation of the Hazards

The climatic and hydrographic pattern significantly varies according to the site.

Regarding climatic aspects, the Tunis region is characterised by a Mediterranean climate with hot dry summers and mild and relatively wet winters. Some exceptional meteorological events serve as reminders of the sporadic violence of the natural elements. For instance, in September 2003, the city received 186 mm of rain in 24 hours, against an annual average of around 456 mm. Casablanca and the Bouregreg Valley are located on the Atlantic coast but their climatic characteristics are close to the Tunis’ ones; the Bouregreg site shows a slightly wetter climate than Casablanca. Though the Alexandria region is one of the wettest in Egypt, it shows a semi-arid climate, with an annual average of about 200 mm. During winter storms (squalls), extreme rainfall intensity can however reach 100 mm/24h.

Climatic projections to the 2030 horizon were performed by Maroc Météo as part of this study, using dynamic downscaling methods from the three ENSEMBLES European project models with IPCC scenario A1B, and the Météo-France ARPEGE-Climat model with IPCC scenarios A1B, A2 and B1. Projections in extreme rainfall events are accompanied by high levels of uncertainty (lack of coherence between models or wide ranges of values, see Figure 14). In accordance with the precautionary principle, the worst case scenario (i.e. the highest assumption) was considered, leading to an increase of 28% for the 100-year rainfall in Tunis, 14% in Casablanca, 25% in the Bouregreg Valley and 30% in Alexandria. These projections were refined depending on the size and features of the catchment areas, in order to determine changes in flood conditions.

Figure 14: Projected Changes (%), as per the different model scenarios, for the number of strong precipitation events (pnl90) and for the 90th percentile (pq90) – Tunis (Source: Maroc Météo, 2010)

With respect to hydrography, the urban drainage basins of the Tunis area consist of numerous small wadis and Wadi Méliane, of which the outfall marks the boundary between Radès and Ezzhara. In Casablanca, the hydrographical network is less dense, with only two waterways crossing the urban area: Wadi Bouskoura in the city centre, and Wadi El Maleh in Mohammedia. The Bouregreg urban development project expands in a deep valley dug by the Bouregreg River. Due to its arid climate and flat topography, the urban drainage basins of the Alexandria conglomeration do not show real hydrographical pattern with well-identified drainage channels. Most of Alexandria’s drainage waters flow towards Lake Maryut, together with the wastewater, through two treatment plants. The lake water level is kept between -2.8 to -2.6 m below sea level, in order to facilitate the drainage of the surrounding agricultural areas.

4.2 Evaluation of the Vulnerabilities

In all considered urban areas, there is a more or less severe risk of flooding in each of the basins due to a variety of factors: inadequate or non-existent upstream drainage networks, poor standard of main water drainage systems, obstacles to flow, low-lying areas downstream of drainage basins receiving rainwater from upstream and subject to effects of downstream levels (lagoon, sebkha, sea), uncontrolled urban development causing increased run-off flows, etc.

The main areas at risk are those fringing the natural depressions (lake and sebkhas of Tunis, Lake Maryut and the former Abu Quir lagoon in Alexandria), or crossed by wadis (Bouskoura and El Melah in Greater Casablanca, Bouregreg, Meliane and other smaller wadis in Tunis). The most exposed districts are densely populated areas such as:

- The pre-war city centre (Basse Ville, Ariana) and the popular districts with informal settlements (e.g. Bardo-Mannouba sector), in Tunis;
- The districts crossed by Wadi Bouskoura from Hay Hassani Anfa to the port, the city centre and the industrial zone of Mohammedia, in the Casablanca region;
- A few “douars” (hamlets), commercial areas and transport infrastructures scattered in the Bouregreg Valley;
- Recently urbanized areas below sea level, between the hydrodrome and Abu Quir, in Sharq and Al-Montaza districts, in Greater Alexandria.

In the 2030 situation, new dwelling areas can be expected in flood prone areas, especially in the Ben Arous – Ezzahra districts and around Sebkha Ariana in Tunis, as well as in sequence 3 of the Bouregreg urban development project. New industrial projects or public facilities can be anticipated in the Casablanca’s city centre and in the Mohammedia sector. There is no planned urban development in sensitive areas of Greater Alexandria (below sea level), but informal settlements may happen if no strict regulation is enforced.

4.3 Risk Assessment / Comparative Analysis for the 4 Locations

In Tunis, the September 2003 flood was estimated to be a 100 year frequency even. Water levels of over 1 m were observed in certain sectors, especially in the wadis Bardo and Gueriana basins (3 août and Enichirah districts in the town of Den Den, Mannouba district), in the Ariana basin (Essanouber district south-east of GAMMARATH) and in the Mégrine area (Lac Sud). Water levels of around 50 cm were observed in numerous other sectors. The total flooded surface area was estimated to be more than 4,500 hectares (see Figure 15).
Figure 15
Tunis flood map

Legend
- Flooded areas for a 100-year return period in the present situation
- Low lying areas
- High areas
- Watershed boundaries
- Main towns

Results obtained by Infoworks modeling on low lying areas, complemented by flooded areas as observed during the 2003 flood.
CLIMATE CHANGE ADAPTATION AND NATURAL DISASTERS PREPAREDNESS IN THE COASTAL CITIES OF NORTH AFRICA

CLIMATE CHANGE ADAPTATION AND NATURAL DISASTERS PREPAREDNESS IN THE COASTAL CITIES OF NORTH AFRICA

Legend
- Sensitive urban components
  - Dense residential area
  - Semi-dense residential area
  - Slums and insalubrious settlements
  - Industrial and commercial areas
  - Port and airport
  - Public facilities
  - High quality agricultural lands
  - Natural areas to be protected
- Hazard
  - Flooded areas
  - Critical areas

Figure 16 Casablanca and Mohammedia flood maps

GED80823T - Phase2_Casa_inondation_EN.mxd - fz - mars2011
In Casablanca, ten “black spots” have been identified by LYDEC which cause frequent flooding in highly urbanised areas and lead to disruptions in the lines of communication. The Bouskoura wadi natural bed crosses the Casablanca urban area and is completely urbanised (see Figure 16). Its flow area is greatly reduced when it passes through the conurbation since the water drainage system’s capacity is 2m³/s (to be compared to the decennial flow rate of 45m³/s). During heavy rainfall, such as in 1996, the city centre was flooded. The El Maleh wadi generated catastrophic flooding in November 2002 in the city of Mohammedia. These floods were aggravated by a number of factors such as the occupancy of the flood plain, the presence of obstacles to runoff, and insufficient hydraulic crossing sections. This flood, with an estimated return period of 65 years, upstream from the El Maleh Dam, was strongly tempered by the dam. The total flooded surface area is estimated to be 5,500 hectares in the whole agglomeration for a 100-year flood.

With regard to the Bouregreg, detailed hydraulic studies were carried out within the framework of the Bouregreg Valley development project. These studies defined the hypotheses to be taken into consideration for forthcoming studies. In the present situation, flooding is generalised in the Bouregreg Valley for the 100-year reference flood; the floods begin in the upstream and central part as from the 10-year flood. The bridges are not submerged for the reference flood. The total flooded surface area is estimated to be 1,800 hectares for the 100-year flood. Most of the commercial and craft activities are situated in the floodplain.

Overall, Alexandria faces a low risk of floods. Runoff water is managed together with wastewater in a combined sewage and drainage network. This network has been improved and upgraded during the last decades, but its discharge capacity is low (equivalent to a 2-year flood event), so overflows at manholes or pumping stations during winter storms are frequent. These floods are of limited extent and usually do not exceed a few hours. As a result, no significant damage because of flooding of the urban areas of Alexandria has been reported, but traffic can be temporarily disturbed (see Figure 17).

Figure 17: A flooded street in the Al-Agmi district of Alexandria after a winter squall (Source Egis BCEOM International, January 2010)
The conditions of flooding to 2030 in the urban parts of the Tunis area were evaluated using a modelling carried out for the 2005 BCEOM-SIRUS study, with new hypotheses on rainfall and the waterproofing of surfaces (increasing urban density), see Figure 18. The climate change hypothesis modifies the frequency of exceptional precipitation events: the 20-year return period rainfall in the current situation becomes the 10-year rainfall, the 100 year rainfall in the current situation is assigned a return period of 50 years in 2030. The rate of waterproofing of ground surfaces goes from the current 31 per cent to 47 per cent in the future. All of the flood protection projects covered in the 2005 study (flood mitigating sills, resizing of some parts of the drainage network, drainage works, pumping station, etc.) are assumed to have been implemented. The effect of urbanisation is often of the same order of magnitude as that of climate change, sometimes greater for the drainage basins in which waterproofing increases greatly. Modelling indicates major overflows from the networks and main branches, as well as overflows from the existing flood regulating basins, often inadequate for the 10-year frequency events in the current situation.

As regards the river flooding or runoff risk in Casablanca, the climate changes taken into account by Maroc Météo between 1960 and 2004 have already shown an increase of 20% in the decennial flow rates. The objective of protection considered in the new sewerage master plan currently under way is 10 years, based on reevaluated intensity-duration-frequency curves. The development of the “Super Collecteur Ouest” (western mega-drainage system) will enable the flood waters from the Bouskoura wadi to be diverted. The project is designed for a return period of 20 years and the drainage system will also receive the runoff from several existing catchment areas or from areas being urbanised. Climate change could however lead to an increase in the flood water flow rates of 15%, which would reduce the protection level roughly from 20 to 15 years. The planned protection works, in particular the dams on the El Maleh wadi and its tributaries, aim to reduce the flood water flow rates at the entrance of the city of Mohammedia. The climate change impact could lead to an increase in flood water flow rates by 15%, excluding the impact of the dams. This impact would only be visible downstream during the 100-year flood, due to the high impact of the dams on lower-degree flooding compared to the 100-year flood (the floods will, in particular, be fully tempered by the Boukerkour Dam until a return period of 100 years; this dam controls approx. half of the catchment area).

In the Bouregreg Valley, the objective of flood protection for the future urban areas has represented a major concern when establishing the valley development project. In this respect, creating secure conditions regarding floods constitutes a prerequisite to the urbanization of the various sequences of the valley development project. Hence, planning permissions are delivered by the Agency for the Development of the Bouregreg Valley only if these conditions are fulfilled. In addition, significant hydraulic works have been carried out before launching the urban sectors, or are underway or planned, such as the creation of a navigation channel, the backfilling of several hectares of areas to be urbanized, the construction of protection dykes for a 100-year flood, the derivation of existing drainage networks, the construction of new collectors for runoff waters and wastewaters, etc. Keeping 370 hectares of urban area out of water, planned in sequence 3 upstream from the ONCF railway line, leads to a maximum rise of water level in the downstream sector of 35cm (results obtained from the 2D model realised during the project’s complementary studies). The hypotheses associated with climate change could lead to an increase of 17% in the peak flow rate of the 100-year flood downstream from the SMBA Dam. This increase would lead to the raising of water levels in the Bouregreg wadi floodable area around +35cm downstream from the Moulay Hassan Bridge, and between +20 and +30cm in the sector between the ONCF Bridge and the bypass. Approx. 100,000 persons (inhabitants + employees) will be potentially exposed to flooding in Sequence 3 (Kasbat Abi Raqraq) of the Bouregreg urban development project.
Figure 18: Simulation of flood impact in the Bardo-Gueriana basin in Tunis, for a 50-year return period (Source Egis BCEOM International – SIRUS, 2005-2010)

- Flooded areas in the present situation
- Flooded areas in the present situation after implementation of the flood protection plan (-80%)
- Limits of the Infoworks hydraulic model
- Flooded areas in the future situation (2030) with climate change impact (+173%)
- Flooded areas in 2030 with climate change and urban development impact (+36%)
In Alexandria, the conditions of flooding may also worsen because of the combined effect of climate change and increasing urbanisation. Overflows of the present sewerage network may become more frequent. The combined effects of climate change and urban growth may double the water level rise in Lake Maryut for a 100 years flood (i.e. + 60 cm). Nevertheless, the situation should stay manageable with regard to the present pumping capacity and water level regulations.

The above considerations lead to the following assessment of the risk level for flood, in the current situation, and in 2030, for the 4 locations:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2030</td>
<td>Very high</td>
<td>High</td>
<td>Very high</td>
<td>Medium</td>
</tr>
</tbody>
</table>

5. Water Scarcity

5.1 Presentation of the Hazards

The four sites are mainly supplied in surface water, either through artificial reservoirs (dams) in Morocco and Tunis, or from the Nile River via the Al-Mahmoudeya Canal for Alexandria. Groundwater is often salinized and/or too polluted for domestic uses.

Because of the dry climatic conditions in the areas under study, water resources management is at stake.

Figure 19: Trend in observed annual rainfall for Rabat (Source: Maroc Météo)

Climate change projections performed using dynamic downscaling models for several greenhouse gas emission development scenarios, show an overall decrease in precipitation:

- In Tunis, a decrease is indicated for cumulative winter and spring falls, although this is small (-1 to -12 % for winter and -1 to -18 % for spring);
Casablanca and Rabat have experienced a clear decreasing trend in annual rainfall (i.e. approximately 2.8mm/year) during the last 3 decades (see Figure 19). The projections for the year 2030 foresee a decrease by 6 to 20%.

In Alexandria, climate change projections do not show significant trend.

5.2 Evaluation of the Vulnerabilities

Water supply to Greater Tunis is mainly via the Mejerda-Cap Bon canal collecting water from the wadis in the north of Tunisia. Flows in the wadis are regulated by numerous dams of which the oldest date from the 1950s (see Figure 20). SONEDE, in charge of water supply and distribution, takes 13% of the available resource from the canal for Greater Tunis' drinking water supply. Most of the remaining water is used for irrigated agriculture.

Figure 20: The Tunisian dam development program (Source: Direction Générale des Barrages et des Grands Travaux Hydrauliques)

Water supply to Greater Casablanca and Bouregreg Valley is provided by two main sources: the SMBA Dam, on the Bouregreg wadi which supplies 38% of Casablanca’s needs, and the El Massira Dam, on the Oum Er Rabia, for the remaining needs. Agriculture, which is the main water use, is also supplied by the Berrechid and Chaouia water tables that are overexploited and heavily polluted.
In Greater Alexandria, the current water needs are estimated to be between 4.5 million \(m^3\)/day (2.5 million \(m^3\) drinking water, 1 million \(m^3\) industrial water, and 1 million \(m^3\) agricultural water) for the summer months and 3.80 million \(m^3\)/day (2.0 million \(m^3\) drinking water, 1 million \(m^3\) industrial water, and 0.80 million \(m^3\) agricultural water) for the winter months. Water supply from the Nile River through the Al-Mahmoudeya canal (5 million \(m^3\)/day discharge) covers the current needs. Almost half of the Egyptian industrial activity is located in Alexandria, and this sector is the major contributor of water consumption in the Alexandria urban area.

In the four urban areas under study, water abstraction and consumption are increasing steadily, at the same pace as the population increases (and even more taking new agricultural or industrial development into account). At the 2030 horizon, the population is expected to grow by 35% in Greater Tunis, 40% in Casablanca and Greater Alexandria.

### 5.3 Risk Assessment / Comparative Analysis for the 4 Locations

Critical situations for the resource are successive dry years.

In the northern part of Tunisia, such situation has been experienced in 1987–1990 and 1993–1995 (drought estimated to 30-year return period). Drought management has been introduced nationally since these successive droughts. In 1994–1995, restrictions were placed on agricultural uses (-30%). Distribution in the main urban areas such as Tunis was not affected, although there was a water quality problem of increased turbidity and salt levels behind the dams. By 2030, if the water resource is not modified, the pressure of population growth alone will push abstraction by SONEDE from the Mejerda-Cap Bon canal from 13% to 20%, or even 32%, with the major urban development projects planned for that horizon. With hypotheses assuming a reduction in the resource (siltation of dams, climate change) of around 15%, these values go respectively to 23% and 37%. The major urban projects account for around 37% of water requirements at the 2030 horizon. These additional needs will probably require calling on other resources so as not to excessively penalise agriculture or other northern Tunisian cities.

In Greater Casablanca and the Bouregreg area, the risk of water shortage is relatively low at present thanks to the important dam construction programme that has been implemented by the Moroccan Authorities for several decades. The availability of surface water controlled by the dams enables the impact of droughts to be contained. At the 2030 horizon, the change in the demand pattern in Greater Casablanca should increase by 1.7% per year excluding major urban projects and by 1.9% per year including major projects. These figures are based on achieving a distribution network yield of up to 80%, which is currently 72%, and on a relative stagnation of unitary consumptions. There may be a significant climate change impact on the availability of the Bouregreg (SMBA) Dam’s resource as average supply could reduce by 30%, or even up to 40%. The Bouregreg Valley urban development project will contribute towards increasing pressure on water resources.

The water resources of Alexandria are becoming scarce, however the current risk of water scarcity is low as the current water supply meets current needs. Surface-water resources originating from the Nile via the Al-Mahmoudeya Canal are now fully exploited, while groundwater sources are being brought into full production. Moreover, aquifers are partially salinized and unsuitable for human consumption. The risk of water scarcity is relatively high for the 2030 scenario as the 50% increase in water needs observed during the last 10 years is expected to continue. With a maximum supply capacity of 11 million \(m^3\)/day, and taking into account the current consumption growth, the Al-Mahmoudeya Canal supply capacity would be exceeded by 2032. Although climate change projections for the Nile River basin are difficult to
carry out, we can assume that the growing needs of all the countries of the catchment’s area will also significantly affect the resource availability.

The above described situations and projections lead to the following assessment of the risk level for water scarcity, in the current situation, and in 2030, for the 4 locations:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bouregreg</th>
<th>Alexandria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2030</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

### 6. Multirisks Approach

The purpose of the present section is to identify possible cumulative effects of natural disaster and climate change risks, and locate the most vulnerable areas in each site under study regarding these cumulative effects.

#### 6.1 Presentation of the Hazards

The following hazards are considered:

- Ground instability and seismicity
- Tsunami and marine submersion
- Coastal erosion
- Flooding
- Water scarcity

All these hazards – except water scarcity – were mapped using GIS, allowing representing cumulative effects in the 4 urban areas, for the present situation and for horizon 2030. For the description of the hazards, refer to the previous sections.

#### 6.2 Evaluation of the Vulnerabilities

The four urban areas under study experience current fast population growth that will continue until 2030.

**Greater Alexandria** has a current population of about 4.3 million people (in 2006). According to future population estimations from the Governmental Organization for Physical Planning (GOPP), Alexandria may reach a population of 6 million inhabitants in 2030, following a 40% population growth. This major growth will translate itself in the urbanization of surrounding areas, threatening critical natural resources, such as Lake Maryut. The strategic planning documents developed by the Governorate of Alexandria show major direction of urban expansion westwards, along both shores of Lake Maryut. However, given the recent trends, it is assumed that urban sprawl will also continue south of the city, between Maryut Lake and Abu Quir.

**Urban sensitive or vulnerable components** within Alexandria city are:

- **Informal or slum areas**: the informal or slum areas covers about 3.25% of the total area of Alexandria but represent about 35.4% of Alexandria’s total population. These areas are mainly located in the central city area (Al-Montaza and Sharq districts, see
Figure 21) and are characterized by high population density, bad building conditions, absence or bad conditions of infrastructure, and high percentage of people living below poverty line.

- **New construction in hazard prone areas**: reclaiming wetlands and other low-lying areas for construction put future population at risk of damages from potential earthquake, land subsidence or flooding.

- **Buildings and infrastructure facing coastline**: Urban components likely to be affected by the coastal erosion and marine submersion risks are port facilities, coastal roads, and dwelling houses on the coastline directly exposed to these risks. The sanitation system is highly sensitive to heavy rains, and in case of overflow, streets and tunnels may be flooded.

The cumulative effect of expected changes to 2030 may be an **increased exposure of the poorer populations** (precarious living conditions), the appearance of **new urban patches** (major projects) on sites relatively exposed to climatic risks (Abu Quir depression, Maryut Lake, shoreline) and by **expansion of informal settlements** in hazard prone areas. In particular, an urban expansion South of Al-Montaza and Sharq district is likely to occur in low-lying areas exposed to flood and seismic risks.

**Figure 21**: Distribution of the slum areas of Alexandria Governorate (Source: GOPP 2006)
The population growth should be moderate in Greater Tunis, with “only” 750,000 more people projected to 2030, giving Greater Tunis a population close to 3 million. Current urbanisation in the metropolis shows “interstitial voids” within the urban patch. The gross habitation density is therefore relatively low over the urbanised area, the greater part of the area being occupied by two storey buildings. The present urban fabric therefore has the potential to accommodate the additional population, as expected in the Greater Tunis Development Master Plan (Schéma Directeur d’Aménagement du Grand Tunis). However, an analysis of current trends indicated continuous low-density extension of the city by building (regulated or not) of new housing, the urban patch tending to extend beyond the natural limits of the site (Tunis basin) with construction on the hillsides and in the flood prone areas on the edges of the wadis and sebkhas. The available data point to a “suburbanisation” of the middle classes, especially in the areas between Lake of Tunis and Sebkha Ariana. The “lower” classes will mainly remain in the denser western and south-western districts of the capital but, with the expected improvement in the built fabric, population densities should reduce and precarious forms of housing gradually disappear. It is assumed that the “major urban projects” situated around the Tunis Lake, around Sebkha Ariana and on the littoral, contributing to the dispersion of tertiary functions will be completed by 2030.

In terms of vulnerabilities, the cumulative result of these changes seems to be a reduction of the exposure of the poorer populations (precarious living conditions), counter-balanced by the appearance of new urban patches (major projects) on sites relatively exposed to climatic risks (Lake of Tunis, shoreline) and by expansion of informal settlements disregarding natural hazards. The most vulnerable urban sector is clearly the “Basse Ville” (lower city), located between the Tunis port and the Medina, which will remain a dense urban pole in 2030, while affected in the meantime by growing risks of flooding, marine submersion and geological instability.

In Greater Casablanca, there has been a rapid two-fold increase in the number of households compared to the population itself which leads to very high urban pressure. In fact, an urban increase of 700 ha to 1,000 ha per year is currently being observed. However, this urbanisation has changed shape. For a long time situated in the immediate extension of the conurbation, and mainly produced by public operations, it has progressively developed “beyond the walls” of the city, taking various forms which more or less comply with the rules of urban development. The SDAU (development and urban planning master plan) hypothetically calculates the population to be 5.1 million inhabitants in 2030, to be compared with the 3.6 million inhabitants in the present situation (+40%). The housing requirements which result from demographic forecasts will be considerable. The recommended development works consist in managing the Centre-City (Casablanca) growth and organising the reception of most of the demographic and economic growth in the outskirts rather than “oil patch” spreading of the city centre.

At present, the main vulnerable areas facing natural risks in the Casablanca region are:

- **Dense residential areas built with poor quality materials** (medina, kasbah, precarious housing areas, poor quality post-war urban housing units, etc.). The seismic hazard, however, is deemed to be sufficiently low so the risks are negligible.

- **As regards erosion and marine submersion risks**, the vulnerable areas are mainly limited to the urbanised seafront bordering the beach between Casablanca and Mohammedia. It should be recalled that tsunami risks, assessed within the framework of this study, are similar to those of the storm surge caused by a 50-year storm.
Regarding flood risks, the at-risk sectors are relatively dispersed and either they have inadequate or badly-equipped storm water drainage systems. Since the hydraulic development of the El Maleh wadi, floods are mainly concentrated in the urban section of the Bouskoura wadi basin. The Mohammedia area is however still threatened by both Wadi El Maleh flooding and marine submersion.

At the 2030 horizon, with the reduction in unhealthy living districts, the tendency to reduce urban density, and the improvement of the quality of construction material, there should be a reduction in vulnerability to seismic risks, even if, with demographic growth, a greater part of the population will be exposed to such risks. On the other hand, the urban strengthening project and the development of major projects all along the coastline may create a conflict of use and contradict the preventive and protection measures linked to climate change, especially in terms of erosion, tsunamis and sea level rise.

As regards the Bouregreg site, there is little vulnerability at present, the valley being used as a land reserve within the framework of a vast urban development programme. The first part of this programme, at the mouth of the river, is being completed. In the future, the valley will undergo significant changes even if the urban sectors are only going to represent 8% of the total surface area of the perimeter. The urban density in these sectors will be rather high to very high (137,600 inhabitants are expected and 88,200 jobs), on a site largely exposed to natural risks: flooding from the Bouregreg, marine submersion, ground instability, and the risk of earthquakes. The development programme needs to carefully integrate such constraints which will generate non-negligible additional costs.

6.3 Risk Assessment / Comparative Analysis for the 4 Locations

The Tunis area is clearly the main urban area at risk regarding natural disasters and climate change impact, among the four sites under study. The reasons are mainly related to a detrimental physical environment: extreme rainfall events, large stretches of the sand beaches exposed to erosion and marine submersion, low lying areas (sebkha, Lower City) worsening flood and marine submersion risks, and subsidence phenomena worsening the seismic risk. As it can be seen on the Figure 22, the Lower City – at high stake with respect to its social, historical and economical value – concentrates all of the risk categories except coastal erosion. The natural disaster and climate change risks are however widely spread over the whole urban area.

Overall, the Casablanca urban area is less exposed than Tunis, these risks being more focused on a few sensitive sites such as city centre along the former Bouskoura river bed and the Mohammedia port and industrial area. However, as shown further in the economic analysis (see Chapter 5), the potential costs of natural disasters and climate change are higher, given the importance of the threatened areas for the national economy. It should be noted that, in spite of a possible 15 to 20% increase in flood water flow rates, the storm water drainage programmes and particularly the western mega drainage system project (Super-Collecteur Ouest) of the Bouskoura wadi should significantly improve the situation. This, however, assumes taking the non-aggravation constraints of flow rates downstream into consideration in urban development planning and land occupancy management of floodable areas. Protection devices are also planned to reduce possible overflows of the El Maleh wadi (two new dams upstream, new dykes and canals downstream).

The Bouregreg Valley is a specific case for at least two main reasons: 1) it is currently a rural area and therefore the present situation cannot be compared to the planned urban development that may welcome 137,600 inhabitants and 88,200 jobs by 2030; 2) the project owner is in a
position to design a urban project protected against a millennium flood, or at least a centennial flood (to be compared to a 5-year return period in Casablanca for the present situation), assuming that the extra costs will be taken in charge by private investors. Protection of urban development areas against floods is a major concern that has been incorporated in the valley development project. It is a prerequisite to the urbanization of the different sequences of the project. The Agency for the Development of the Bouregrg Valley committed itself to reject any construction project if these conditions are not fully complied with. Moreover, prior to urban development, significant protection works, such as hydraulic works related to the navigation channel, filling up several hectares of platform to be urbanized, construction of protection dykes against a 100-year flood, deviation of existing drainage systems, etc., have already been implemented or are underway or planned. Regarding landslide risks, the Bouregrg Valley Development Plan prevents any construction in zones likely to be affected by erosion risk, rock fall and gullying. These zones are maintained in their natural state, as forest reserves or protected natural areas. Therefore, this site definitely cannot be directly compared to the three other urban areas.

As to the Alexandria urban area, it is very similar to the Tunis urban area in many aspects: large stretches of sandy beaches exposed to erosion and marine submersion, low lying areas (Lake Maryut, depression of the former Abu Quir lagoon) worsening flood and marine submersion risks, and subsidence phenomena worsening the seismic risk. However natural hazards are estimated to be significantly lower than in Tunis. This situation could however worsen because of higher rates of informal settlements and slum areas that can lead to urban sprawl in areas at risk, especially the lowlands between Lake Maryut and Abu Quir.

In all urban areas under study, the main natural risk is flooding. It is also the main risk likely to be significantly worsened by climate change. Marine submersion (either by storm surge or by tsunami) can be ranked second and will also be affected by climate change, through the sea level rise phenomenon. Coastal erosion is an issue shared by all these coastal cities, but its impact can be relatively well handled, at least till 2030 (with higher sea level rise, this risk may become crucial). The seismic risks seem at stake mostly for the Tunis urban area. Last, water scarcity is not presently at risk in the four urban areas, and it is difficult to make a clear statement on that issue for 2030, given high climate change uncertainties and the geographical scale of water resources management, which largely exceeds the areas under study. However, we can estimate that Alexandria (and the whole Egypt), which only depends on one source of water supply – The Nile River – may face significant problems in the long term.
Figure 22
Multirisks map of the Lower City in Tunis

Legend

Flood Hazard
- Flooded areas (100 years)
- Infoworks RS modeling

Marine submersion hazard
- Submerged area

Subsidence
- Mean evolution of subsidence between 2003 and 2009
- ENVISAT data analysis (TRE, 2010)
  - 0 - 2.5 mm/year
  - 2.5-10 mm/year
  - >10 mm/year

Microsoft Virtual Earth - ©2009 Microsoft Corporation
Figure 23
Multirisks map of the Bouregreg Valley

LEGEND

Sensitive urban components by year 2030
- Dense residential area
- Semi-dense residential area
- Industrial and commercial areas
- Port
- Main roads and railway
- Public facilities
- Natural areas to be protected or to create
- Urban site of high heritage interest
- Site boundaries

Aléas
- Geotechnical hazard: instable slopes
- Seismic hazard: compressible soils
- Submerged areas
- Flood hazard (Q100)
Chapter 4 – Adaptation and Resilience Action Plans

This chapter presents the main results of the second phase of the study devoted to draw up an adaptation and resilience action plan for the four urban areas.

1. Main Orientations

To address the risks and vulnerabilities identified in the previous chapter, a set of recommendations has been drawn up, under the form of action sheets (see methodological aspects in Chapter 2, Section 3.2.).

Within each category of risk, the sheets were classified according to the sphere of intervention:

- Recommendations concerning the institutional preparedness and emergency plans of the urban districts in view of climate change impacts and disaster risks;
- Recommendations for urban planning aimed at minimizing the vulnerabilities identified: specific recommendations in terms of land-use and urban planning that would facilitate the adaptation of the urban locations to the changing climate and increase their resilience to natural disasters. Such recommendations refer to the existing urban coverage and to the projected urban development until the 2030 scenario;
- Recommendations concerning the infrastructure assets and the physical investments that will be required to protect or upgrade the urban assets and systems in order to adapt: coastal marine defenses, key urban infrastructure hot-spots, water supply and drainage systems, buildings …

The first two spheres of intervention correspond to strategic axes, dealing with risks in a global and cross-disciplinary way. The third one refers to a more thematic and technical approach of risks and vulnerabilities. Moreover, the institutional area is more “preparedness” oriented, while urban planning is rather a “prevention” approach, the technical measures and physical investments being devoted to the “protection” of assets and populations.

2. General Presentation of the Recommendations

The present section is aimed at giving an overview of all recommendations. The following tables display all the recommendations drawn up for the four sites under study, starting first by the common recommendations, relevant for all sites, then the recommendations specific to each site. The recommendations are presented by risk category. A tentative scheduling of the recommendations is proposed: very short term (< 2 years), short term (< 5 years), medium term (> 5 years). Some comments are given regarding the priority level of each recommendation.

A brief description of the most important recommendations is provided in Section 3 hereafter.
## COMMON RECOMMENDATIONS TO ALL URBAN AREAS

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional coordination for natural disaster preparedness and climate change adaptation</td>
<td>X</td>
<td>The whole action plan requires strengthening coordination and cooperation between the various ministries and organisms concerned. Early warning especially needs good coordination.</td>
</tr>
<tr>
<td>Advance planning, operational response and rationalization of natural disaster risk-management procedures</td>
<td>X</td>
<td>Is the « operational » equivalent of the previous action. Important benefits expected for a relatively low investment (monitoring network).</td>
</tr>
<tr>
<td>Strengthening the monitoring and early warning system</td>
<td>X</td>
<td>Early warning systems, including both ascending and descending alerts, are the most cost effective actions (investment is relatively small while benefits can be huge).</td>
</tr>
<tr>
<td>Adaptation of early warning systems to risks of strategic nature</td>
<td>X</td>
<td>Action dealing with risks related to climate change on the long term. Is less urgent than the previous action on « tactical » management of natural risks.</td>
</tr>
<tr>
<td>Preparedness and self-protection against fast-impacting phenomena</td>
<td>X</td>
<td>Individuals are the first actors of their protection. This action is to be implemented as soon as possible, but requires first strengthening of the early warning system.</td>
</tr>
<tr>
<td>Future mechanism for natural risk insurance</td>
<td>X</td>
<td>Launching a mechanism for natural risk insurance requires first a better knowledge of the risks, and also prior implementation of all collective measures aimed at reducing the risks.</td>
</tr>
<tr>
<td>Implementation of building and urban regulations</td>
<td>X</td>
<td>The effective enforcement of existing urban planning regulations and revision of some of them to incorporate climate change and natural disaster issues is a first priority.</td>
</tr>
<tr>
<td>Urban zoning and regulations to prevent exposure to risk</td>
<td>X</td>
<td>Is the main urban planning measure to be implemented. Requires however a thorough knowledge on hazards and vulnerabilities.</td>
</tr>
<tr>
<td>Integration of climate change adaptation and mitigation measures in an urban management mechanism</td>
<td>X</td>
<td>This action first requires a better knowledge on natural risks and the effective enforcement of existing urban planning regulations.</td>
</tr>
<tr>
<td>Corridors of green and open spaces</td>
<td>X</td>
<td>Strategic measure coming with all actions aimed at preventing floods and heat waves.</td>
</tr>
</tbody>
</table>
## Recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very short term</strong></td>
<td><strong>Short term</strong></td>
<td><strong>Medium term</strong></td>
</tr>
<tr>
<td>Piloting a climate change risk sensitive urban plan for new expansion areas</td>
<td>X</td>
<td>This action first requires a better knowledge on natural risks and the effective enforcement of existing urban planning regulations.</td>
</tr>
<tr>
<td>Integrated environmental approach of urban planning</td>
<td>X</td>
<td>Lower priority than actions intended to already existing risk-prone areas, but to be implemented for all major projects of urban development.</td>
</tr>
<tr>
<td>« Eco-district » concept for the development of new urban areas and urban renovation projects</td>
<td>X</td>
<td>Is the same as the previous action, but at a smaller scale.</td>
</tr>
</tbody>
</table>

### Management of Ground Instability / Seismicity

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry out seismic microzoning and take it into account in the urban development plans</td>
<td>X</td>
<td>This action is a priority for Alexandria, Tunis and the Bouregreg Valley, in order to take seismic risks into consideration in urban development plans and to enable the vulnerability assessment of existing buildings.</td>
</tr>
<tr>
<td>Develop the earthquake recording and surveillance system</td>
<td>X</td>
<td>Recording / surveillance systems already exist in the three countries. The purpose is to strengthen it.</td>
</tr>
<tr>
<td>Assess the seismic vulnerability of existing buildings</td>
<td>X</td>
<td>To carry out these evaluations, it is necessary to refer to the national seismic zoning (to be set up for Tunisia), and if possible to the microzoning of each urban area.</td>
</tr>
</tbody>
</table>

### Control of Coastal Erosion and Marine Submersion

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amend the legislative framework governing maritime public property</td>
<td>X</td>
<td>To be implemented as soon as possible to enable an effective management of coastal erosion and marine submersion issues</td>
</tr>
<tr>
<td>Improve knowledge on tsunamiogenic sources</td>
<td>X</td>
<td>Is necessary to refine the local zoning of the tsunami risk.</td>
</tr>
<tr>
<td>Local zoning of the tsunami risk and damage scenarios</td>
<td>X</td>
<td>Will allow refining the tsunami warning system.</td>
</tr>
<tr>
<td>Set up a tsunami downward warning system</td>
<td>X</td>
<td>First requires the ascendant warning system currently developed at international level to be operational. Does not seem necessary for Tunis, due to low risk of tsunami.</td>
</tr>
<tr>
<td>Improve knowledge on the changes of coastal beaches</td>
<td>X</td>
<td>To be initiated relatively quickly, to allow planning and launching subsequent coastal protection works.</td>
</tr>
<tr>
<td>Preventing marine submersion risks</td>
<td>X</td>
<td>Requires first a vulnerability study to be carried out, in order to determine the appropriate protection measures. This action also includes specific recommendations regarding submersion risk warning system.</td>
</tr>
</tbody>
</table>
### Recommendations and Scheduling

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flood Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early warning system, emergency plans and public awareness</td>
<td>Very short term</td>
<td>X</td>
</tr>
<tr>
<td>Manage floods in urban areas</td>
<td>Short term</td>
<td>X</td>
</tr>
<tr>
<td>Cleaning and maintenance program of sewage combined networks and drainage networks</td>
<td>Medium term</td>
<td>X</td>
</tr>
<tr>
<td>Enhancement of the current protection level against floods and Master Plan update</td>
<td>Very short term</td>
<td>X</td>
</tr>
<tr>
<td>Control runoff discharges in future urbanized areas and in urban renewal programs</td>
<td>Short term</td>
<td>X</td>
</tr>
<tr>
<td>Reduction of vulnerability in flooded areas</td>
<td>Medium term</td>
<td>X</td>
</tr>
<tr>
<td>Development and management of dykes</td>
<td>Very short term</td>
<td>X</td>
</tr>
<tr>
<td>Optimisation of dam management in flood situation</td>
<td>Medium term</td>
<td>X</td>
</tr>
<tr>
<td>Control and reduction of runoff discharges in existing urban areas</td>
<td>Very short term</td>
<td>X</td>
</tr>
</tbody>
</table>

**Water Scarcity Management**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control and optimization of water consumption</td>
<td>Very short term</td>
<td>X</td>
</tr>
<tr>
<td>Optimisation of water resources management</td>
<td>Medium term</td>
<td>X</td>
</tr>
</tbody>
</table>

**Heat Waves Management**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioclimatic principles of urban planning and architecture</td>
<td>Very short term</td>
<td>X</td>
</tr>
</tbody>
</table>
## RECOMMENDATIONS SPECIFIC TO THE TUNIS URBAN AREA

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very short term</strong></td>
<td>Short term</td>
<td>Medium term</td>
</tr>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban approach of risk prevention for the Tunis « Low City »</td>
<td>X</td>
<td>Requires thorough knowledge of risks on this area, especially regarding subsidence phenomena. This action could guide vulnerability reduction works.</td>
</tr>
<tr>
<td>Strengthening urban planning regulations in Tunis</td>
<td>X</td>
<td>Is aimed at avoiding illegal urban expansion in the Tunis periphery. Requires integration of natural risks and climate change issues in urban planning regulations.</td>
</tr>
<tr>
<td><strong>Management of Ground Instability / Seismicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting up a national seismic zoning in Tunisia</td>
<td>X</td>
<td>Can be established simultaneously to the seismic microzoning of Greater Tunis, which is more a geological than a seismic approach.</td>
</tr>
<tr>
<td>Analysis of subsidence phenomena and landslide hazard zoning of the Tunis urban area</td>
<td>X</td>
<td>Is of particular importance for the « Low City » of Tunis.</td>
</tr>
<tr>
<td><strong>Control of Coastal Erosion and Marine Submersion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting up an erosion control strategy between Rades and the Sellene wadi (southern part of the Tunis Gulf)</td>
<td>X</td>
<td>Requires responsibilities with respect to the Maritime Public Property to be clarified and the enforcement of non-construction principles on the coastal area.</td>
</tr>
<tr>
<td>Monitoring and maintenance of the coastal stretches between Gammarth and La Marsa, Carthage and la Goulette (central part of the Tunis Gulf)</td>
<td>X</td>
<td>Is not urgent and can therefore be planned after the other actions of coastal protection.</td>
</tr>
<tr>
<td><strong>Flood Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limitation of runoff flows towards Sebkha Sedjoumi and protection of the surrounding areas against flood</td>
<td>X</td>
<td>Can be planned independently of the actions related to Sebkha Ariana.</td>
</tr>
<tr>
<td>Control of urban scattering to enable runoff control</td>
<td>X</td>
<td>Urgent measure that will be facilitated if setting up « green corridors » determining <em>non aedificandi</em> areas.</td>
</tr>
<tr>
<td>Protection investments against floods to be implemented in the Low City of Tunis</td>
<td>X</td>
<td>The lowest district of Tunis is the most vulnerable of the agglomeration and deserves therefore to be ranked first priority with regards to protection investments (works and infrastructures intended to flood control).</td>
</tr>
<tr>
<td>Management of the lake and port water level to reduce flood risks</td>
<td>X</td>
<td>This measure is essential for the protection of the Low City against flooding and marine submersion.</td>
</tr>
</tbody>
</table>
Protection investments against floods to be implemented in the Bardo-Gueriana catchment area | X | After the Low City sector, it is the most vulnerable Tunis area.

Protection investments against floods to be implemented in other catchment areas of Greater Tunis | X | This set of 8 action sheets describes the physical investments to be carried out in the following catchment areas: Sebkha Ariana, Sidi Daoud, Guereb-Roriche, West Sejoumi, Fouchana-Mhamdia, EL Mourouj, El Ouardia - Djebel Djelloud, Ben Arous, Rades, Ezzhara, Hammam Lif, Hammam Chatt. These investments are considered less urgent than the previous ones.

### RECOMMENDATIONS SPECIFIC TO THE CASABLANCA URBAN AREA

<table>
<thead>
<tr>
<th>Recommendations</th>
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</tr>
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<tbody>
<tr>
<td><strong>Very short term</strong></td>
<td><strong>Short term</strong></td>
<td><strong>Medium term</strong></td>
</tr>
<tr>
<td><strong>Control of Coastal Erosion and Marine Submersion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection of the vulnerable urban areas along the Casablanca’s shoreline</td>
<td>X</td>
<td>Is aimed at incorporating coastal protection actions in a structured approach of urban planning.</td>
</tr>
<tr>
<td>Protection of Mohammedia against marine submersion</td>
<td>X</td>
<td>Is at stake for both human and socioeconomic considerations (one of the most important industrial areas in Morocco).</td>
</tr>
<tr>
<td>Definition of an erosion control strategy between Mohammedia and Casablanca</td>
<td>X</td>
<td>Mainly concerns the « strategic retreat » principle, to be implemented in the long run.</td>
</tr>
<tr>
<td>Local hazard zoning and damage scenarios related to tsunamis for the Casablanca region</td>
<td>X</td>
<td>Will enable to refine the tsunami early warning system.</td>
</tr>
<tr>
<td><strong>Flood Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood risk control in the Chaouia plain</td>
<td>X</td>
<td>Non-aggravation of runoff conditions in the upstream areas of Casablanca is a priority.</td>
</tr>
<tr>
<td>Control of runoff flows on the Bouskoura wadi basin and management of extreme floods</td>
<td>X</td>
<td>Is aimed at optimising the future « West Super-Collector » (Super-Collecteur Ouest). Is strongly connected to the previous action.</td>
</tr>
<tr>
<td>Assessment and management of flood risks in Mohammedia (El Mellah wadi)</td>
<td>X</td>
<td>Since the construction of upstream dams, the Mohammedia sector is less threatened by floods. It is however necessary to check that the existing and planned protection infrastructures are correctly designed, taking climate change into account.</td>
</tr>
<tr>
<td>Resorption of the urban fabric types vulnerable to flooding</td>
<td>X</td>
<td>This measure of renovation of the urban fabric located in flooded areas is a long term action.</td>
</tr>
</tbody>
</table>
### RECOMMENDATIONS SPECIFIC TO THE BOUREGREG URBAN AREA

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very short term</strong></td>
<td><strong>Short term</strong></td>
<td><strong>Medium term</strong></td>
</tr>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resorption, strengthening and redevelopment of informal settlements overhanging the Bouregreg Valley</td>
<td>X</td>
<td>Requires first a zoning of landslide hazards.</td>
</tr>
<tr>
<td><strong>Management of Ground Instability / Seismicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landslide hazard zoning of the Bouregreg Valley</td>
<td>X</td>
<td>Is an important component of the risk prevention plan and determines the resorption of informal settlements overhanging the Bouregreg Valley.</td>
</tr>
<tr>
<td><strong>Flood Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modify the urban development plan of the Bouregreg Valley to take climate change impacts into account</td>
<td>X</td>
<td>Consists in the integration of the natural risks prevention plan within the urban development plan of the Bouregreg Valley.</td>
</tr>
<tr>
<td>Adaptation of urban shapes and densities of the Bouregreg Valley urban development plan</td>
<td>X</td>
<td>Specifies appropriate shapes and densities to cope with flood risks in the Bouregreg Valley.</td>
</tr>
</tbody>
</table>
### RECOMMENDATIONS SPECIFIC TO THE ALEXANDRIA URBAN AREA

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Scheduling</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Very short term</td>
<td>Short term</td>
</tr>
<tr>
<td><strong>Multiple Risks Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proactive measures for protecting the urban population prone to natural disasters: Abu Quir Area</td>
<td></td>
<td></td>
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<tr>
<td>Proactive measures for protecting the urban zones prone to natural disasters: El Max Area</td>
<td></td>
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</tr>
<tr>
<td><strong>Control of Coastal Erosion and Marine Submersion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventing sea submersion risks in the Abu Quir Bay</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Improve knowledge on the changes of the beaches along the Corniche Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water Scarcity Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reuse treated wastewater and sludge</td>
<td></td>
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</tr>
</tbody>
</table>
3. **Definition of Priorities**

From the whole set of recommendations above presented can be distinguished those deemed to be the most effective and/or those that condition the effectiveness or the feasibility of other actions (upstream actions). To give an idea of the format and content of these recommendations, some examples of the recommendations sheets prepared in Phase 2 are shown in Appendix 1.

The **first priority actions**, with respect to identified issues at stake and anticipated benefits, are mostly the domain of the institutional and urban planning spheres. Indeed, these actions cover the whole range of natural risks (synergized effects), are not expensive, are “no regret” or robust actions, and are flexible / reversible. Investments of high priority mostly deal with the protection of the most vulnerable parts of the urban areas under study (e.g. the Lower City of Tunis).

A minimum "package" of actions for each of the four urban sites is identified below, making clear distinction between common or specific recommendations depending on the sites, including institutional preparedness, urban planning and infrastructure investment measures.

### 3.1 Common Recommendations

On the whole, the following recommendations are considered relevant for the four urban areas under study.

**Institutional measures**

- **Strengthen institutional coordination** for natural disaster preparedness and climate change adaptation: essentially, these measures aim to improve the efficacy of the chain of command in managing sudden-impact natural disaster risks (such as earthquakes and related phenomena, extreme rainfall and coastal submersion), and of the chain of knowledge - study - technical decision-making for vulnerable areas.

- **Advance planning, operational response and rationalization of natural disaster risk-management procedures**: in coordination with the previous action, short-term operating efficiency, especially when dealing with events whose return periods are measured in centuries (earthquakes, for example), could gain from substantially simplifying procedures and reducing the number of institutional interlocutors. Decentralization of part of the response chain is recommended.

- **Strengthen the monitoring and early warning system**, through a set of urgent, structural actions to assist in improving preparedness and potential of response at the national level. Improved capacity in monitoring the territory, and modelling and forecasting natural disasters in the short term, is considered to be the main pathway to come in control of the slow approaching, and (later) fast impacting effects of Climate Changes.

- **Preparedness and self-protection** against sudden-impact phenomena (see also Appendix 1): prepare individuals and families to commonly carry out the required protective actions in situations of imminent danger or unfolding disasters. For the system to function, government departments must provide information on the risk scenario in a timely manner and backed by the appropriate communication resources.
• Amend the legislative framework governing maritime public property: before designing and launching protective actions to counter the risks of submersion and erosion related to sea level rise, it is recommended to suppress the fragmentation of competences with regards to managing maritime public property.

• Flood monitoring and warning system: establish a flood forecasting and warning system to maximize flood preparedness and establish disaster recovery actions; inform the inhabitants and businesses exposed to the flood risk; set up disaster emergency plans at several levels, including specific plans for public buildings.

**Urban Planning Measures**

• Effective implementation and enforcement of building and urban regulations that respond to the climate change risks, and integration of climate change adaptation and mitigation measures within an urban management mechanism. In new expansions, the implementation of a pilot project that demonstrates a risk-sensitive urban planning model is suggested, and could be replicated in other areas.

• Urban zoning and regulations to prevent exposure to risk: a prescriptive "Natural Risks Prevention" regulation, similar to those implemented in France, should be prepared to regulate urban development in areas where the risk of natural disaster is high. Development could be prohibited or authorized under certain conditions, according to the level of risk. The goal is to avoid increasing vulnerability and, where possible, to reduce it.

• Corridors of green and open spaces to reduce risk: is aimed at re-establishing the equilibrium between cities and the environment. In a metropolitan area, these corridors connect conservation areas (not zoned for urban development), because they have a role to play in flood reduction, protection from dominant warm winds, protection against marine submersion (dune-dike), as well as in maintaining biodiversity.

• Carry out or finalize seismic microzonings and integrate the findings in urban development planning: Tunis, Alexandria and the Bouregreg Valley are exposed to 'site effects', namely the amplification of seismic waves. An analysis of the phenomena of subsidence and terrain movement zoning would supplement and refine seismic microzoning. The Tunis and Alexandria subsoil is not only highly susceptible to soil liquefaction, but is also characterized by significant settlement or subsidence movement. It would be desirable, in the case of the Bouregreg, to also conduct a detailed analysis of instability risks on the slopes of the valley.

• Urban development regulation in floodable areas and management of overflows: development could be prohibited or authorized under certain conditions, according to the level of risk. The goal is to avoid increasing vulnerability. For example, base levels should be set according to reference flood levels. The high levels of uncertainty involved in climate change should be incorporated in safety margins for currently undeveloped areas.

• Surface run-off management for new districts or urban renewal programs (see also Appendix 1): if not backed by measures designed to prevent surface run-off flows downstream, urban development will lead inevitably to substantially reducing or neutralizing the effect of protective measures. Accordingly, urban development regulations must make mandatory provisions to ensure that downstream surface run-off is not increased. With respect to master plans, such as plans for new districts, it is vital to incorporate rainwater systems in the urban development plan, particularly by reserving space for the storage and infiltration of rainwater.
• Although lower on the priority spectrum, we would also cite Environmental Urban Planning and “eco-districts”, which integrate sustainable development concerns as part of the design and construction of urban planning or urban development projects, in particular as regards resilience in the face of natural risks and adaptation to climate change.

Investments or technical measures

• Improve knowledge of changes to coastline beaches: knowledge of the risk of coastline erosion and marine submersion remains partial and deficient. In particular, beach characteristics (width of the foreshore, altimetry, sediment type and granulometry, available sand thickness) and their evolution according to hydrodynamic conditions are not known to date, with the exception of some limited coastal stretches. If the morphological developments and hydrodynamic characteristics along the coastline were known with more certainty, the protective measures that may be required if sea levels continue to rise could be adapted accordingly.

• Maintain hydraulic systems and works to reduce the risk of flooding: generally speaking, it is recommended to strengthen maintenance of hydraulic systems and works to guarantee optimum functioning and durability.

3.2 Recommendations Specific to the Tunis Urban Area

Institutional measures

• The general recommendations could be completed by the establishment of a national earthquake zoning and appropriate earthquake regulations, prior to earthquake microzoning and prior to completing a vulnerability assessment of buildings or strategic areas.

Urban Planning Measures

• Urban approach to risk prevention in the Lower City (Basse Ville): an integrated, multi-risk approach is proposed for the entire Lower City area, where flood, submersion, seismic and subsidence risks co-exist and are exacerbated by the effects of climate change. The approach combines environmental urban development measures, applicable to public spaces and to the overall layout plan of the Lower City, with bioclimatic architecture measures and steps to consolidate buildings threatened by subsidence.

• Control of urban scattering to control surface run-off around the Tunis agglomeration: a scale of coercive measures to limit or even halt illegal construction around the periphery of Tunis, from fines to site closures and demolition.

Investments or technical measures

• Flood protection investment in the Lower City area: as some areas are very low-lying, evacuation by pumping is proposed, in combination with controlling the water level in the lakes. These recommendations ought to be included in the flood control master plan currently being formulated for the Lower City area of Tunis.

• Control the water levels in the lakes and the port of Tunis to reduce flood risk: aimed at limiting rising water levels in the lakes (Lac Nord and Lac Sud) in the event of high sea levels. Water level control works are proposed to regulate the water level in the lakes.

• Limit inflows in the sebkhas and provide flood protection for riparian areas: the dense urban development around the sebkhas call for specific precautions (increasing the
pumping capacity, preservation of the existing natural areas, raising some road stretches, …).

3.3 Recommendations Specific to the Casablanca Urban Area

Urban Planning Measures

- **Protection of the vulnerable urban developments along the coastline**: these measures target the current or planned urban developments along the Casablanca coastline. It aims to provide proposals to improve and to reduce the vulnerability of Casablanca’s coastline and urban seafront to erosion and marine submersion risks, exacerbated by the accelerated rise in sea levels.

Investments or technical measures

- **Protection of Mohammedia against marine submersion** (Casablanca urban area): the greatest impact of high swells in stormy conditions will potentially be felt in the most low-lying areas where the wadis meet the sea. Part of the flood plain of the El Maleh wadi and of Mohammedia would actually be submerged if storms brought exceptionally high sea levels. The stakes are high, as the area is densely populated and is home to industrial and port activities that are of national importance. The only protection that can be envisaged is the construction of raised dikes. These protective measures must also include urban and institutional planning measures designed to mitigate vulnerability.

- **Upgrade the Greater Casablanca sanitation master plan**: following a reassessment of Casablanca’s characteristic rainfall (taking account of climate change in the last few decades), the rainfall master plan needs to be updated to establish a diagnostic and design the works required to ensure protection for at least a 10 year return period. Climate change is to be taken into account for sea level rise and increased extreme rainfall beyond this return period.

- **Control flood risk in the Chaouia plain**: maintaining the existing wadi flood plains and flood expansion areas is strongly recommended; this concerns the Merzeg wadi, the Chaouia upstream basin and the Berrechid plain. Controlling and managing floods in the Chaouia plain is an important part of the flood prevention strategy in the Casablanca urban area. Flooding in the Chaouia plain also affects Casablanca’s key connection infrastructure (motorways and railways).

- **Control surface run-off in the Bouskoura wadi basin and manage exceptional flooding**: the stretch of the Bouskoura wadi traversing Casablanca has disappeared completely as a result of urban development, which generates recurrent flooding. In addition to the Western mega-drainage project (Super-Collector Ouest), setting up overflow sectors is recommended to prevent flooding of the most vulnerable areas (particularly Casablanca city centre), while overflow areas in new neighborhoods should be retained.
3.4 Recommendations Specific to the Bouregreg Valley Urban Project

**Urban Planning Measures**

- Update the urban development plan for the Bouregreg to incorporate the impacts of climate change, especially with respect to the maximum flood level projections. The goal is to amend zoning regulations for areas to be developed and to revise the minimum reference dimensions for the dikes and areas zoned for development. Combined with this review, recommendations include optimizing real-time management of the SMBA Dam during flood periods, and limiting the vulnerability of the urban developments in the wadi flood plain, in particular by ensuring that building layout does not create an obstacle to run-off (maintaining hydraulic transparency zones).

3.5 Recommendations Specific to the Alexandria Urban Area

**Investments or technical measures**

- Better evaluation of national risks by improving knowledge of tsunamigenic sources in Egypt (location, seismic nature, gravitation, size, probability of occurrence, etc.).

- Undertake proactive measures towards the protection of urban zones prone to natural disasters both in Abu Quir and ElMax areas of Alexandria. Both areas are prone to natural threats (especially marine submersion) and include important national and local socio-economic assets. The purpose of those actions is to shift the emphasis of the disaster management from post-disaster response to pre-disaster proactive actions involving preparedness and prevention. See also Appendix 1.

4. Implementation Conditions

The different recommendations of the action plan are under the responsibility of the government services and state organisations identified on each sheet. To coordinate the initiative and monitor the implementation of the different actions, it would be desirable to nominate a coordinating body. It is clear that the selection of such entity will be the choice of each Government, and that not necessarily those national agencies that have been coordinating the study in each country will be in charge of implementation. Nevertheless there is accumulated knowledge and institutional commitment, achieved via significant consensus building, in the national institutions which have been responsible for the study in each of the countries, which can be very useful for the next phase of decision-making. It is also recommended that the representatives of the local governments be more directly involved in the preparation of the implementation phase, so as to ensure additional local ownership and support to the adaptation and resilience action plans.

These organizations will have to consult with the Ministries in charge of Finance and Foreign Affairs in order to set out the financial arrangements for the project. It is in fact fairly unlikely that the local governments will be able to finance all the actions out of their own funds, so some international aid will have to be requested. Multilateral development agencies and the main economic partners could be approached. As soon as possible, these partners should be approached for the launch and financing of any additional studies required for the implementation of the action plan (drawing up of the ToR, launch of consultations, selection of the consultants). The operations to be launched first are those defined above as priority.
Around the coordinating body, a **steering committee** could be set up which brings together the financial partners and the main authorities concerned by the action plan, namely:


Under the aegis of the coordinating body, this steering committee could meet every three months to review the progress of the action plan.
Chapter 5 – Institutional Analysis

This chapter provides an overview of the main limitations of current institutional set-ups in the three Countries dealt with, and a few recommendations on how to strengthen them for an effective implementation of the resilience and adaptation action plans.

The Phase-1 analysis of the current management systems of Natural Risks, or Climate Change related risks, has identified **structural and/or functional weaknesses** which appeared to require modifications either of a purely technical nature, or institutional or indeed a mix of both.

For obvious reasons of feasibility and admissibility, the suggested structural improvements presented below, exclusively address the technical and technical-institutional aspects. which have been brought to light by the beneficiary's and partners' needs analysis. Apart from suggestions made for internal improvements to the system, increasing its efficiency, as is customary, we voluntarily refrained from dealing with issues directly relating to, or having influence on internal political decisions.

The institutional cartography (who is doing what) in each country is presented in **Appendix 2**.

1. Present Situation in Tunisia and Recommendations

1.1 Limitations of the current Institutional Context

The overall structure and approach for the management of natural disasters in Tunisia, have hardly changed **between 1991 and the present day**. This is, no doubt, linked to the fact that Tunisia was “relatively” spared during this period, and the public Authorities did not deem it useful to make major changes to the current organisation, in spite of the several faults that were highlighted during the floods of 1995, 2003, 2006, 2007 and 2009.

The system as it was designed and established by Law No. 93-121, remains focused on “response”, viewed as all of the emergency actions that can be taken to deal with an event, whereby national security measures were shifted onto the existing "military-civilian” dual system. This system, which is shared by all three Countries studied, is **largely based on preparation** (ORSEC planning) rather than prevention. It is therefore subject to an intrinsic weakness in relation to natural disasters, whose times and locations of hit are unpredictable, on one hand, and incomparable to the climate change related risks, such as the sealevel rise, whose effects are predictable with sufficient advance and accuracy. In both cases, however, risk reduction goes hand in hand with a preliminary vulnerability reduction.

We have noticed that the efficiency of the current method of emergency response is mainly undermined by a **strongly centralised, decision-making mechanism** involving a **redundant institutional representation**, overwhelming an automatic response reflex and and weakening the response efficiency in major emergencies.

A gentle though firm inversion in trend took place in 2010, with an attempt at rationalising the nationwide available, science and technique, risk oriented knowledge and know-hows. However, major structural weaknesses in risk management and crisis response are still
associated to (i) the insufficient rank of the National Office for Civil Protection (ONPC) within the wide fan of Institutions formally involved in the management of risks at the national level, and (ii) the lack of real decision and action power at the level of the Municipalities.

1.2 Recommendations

A. GENERAL ASPECTS

In general, the study has shown that in both cases (slow or fast impacting phenomena), the decision making should be concerned mainly with the improvement and continuous update of quantitative knowledge of territorial parameters, as well as the action resulting from it. Indeed, the Society's resilience to major risks is formed in advance with the help of an interlinking but simultaneously flexible organisation and preparation, which lead to a reduction in vulnerability and which optimise emergency response.

Therefore, the prevention methods should be oriented first and foremost towards a confinement of the impacts of the event, making sure that the most efficient resources are made available as near as possible to the affected area.

The slow-moving process of Climate Change related events calls for action on a multi-decennial scale, allowing time to work on urban planning and institutional architecture on a generous time and space-based scale, with time to spend on re-designing, spacing, displacing, re-housing entire communities in order to save their goods and in some cases their lives.

B. GEOPHYSICAL RISKS

According to historical analysis, it has been ascertained that the intensity of the occurrence of earthquakes expected in the "Grand Tunis" area is on a scale of VII (modified Mercalli scale) for the period of return occurrence after 475 years, whereas it is located at around VI for a return occurrence after 50 years. These are relatively modest events involving moderate theoretical acceleration and they are relatively easily absorbed by buildings conforming to the current codes of calculation and construction in seismic zones. However, there is a need for specific mapping data along with the implementation of para-seismic improvement measures, which would impact on the urban planning of the Grand Tunis area.

The lack of historical evidence and the morphology of the coastline and seabed in the Grand Tunis area, suggests that the risk of a Tsunami is negligible. Similar but much more probable and frequent phenomena, such as storm tides, seem to be more manageable by the prevention system because a even a very-short term forecast ("now-cast") can prove effective provided that the response has been prepared in advance. The short term and the very-short term forecasts for exceptional meteorological events are normally in the reach of Tunisian institutions and in particular of INM: however, the latter should still prove efficiency in the new legal framework that concentrates in his hands the whole work of prevention and forecast for meteorology, earthquakes and tsunamis, including Early Warning. In the transition towards an autonomous system, the success percentage in forecast and in scenario building, worth being improved via the activation of international cooperation protocols.

The technological effort proposed in the action plan, the dynamics of the hydraulic coastal phenomena both those which hit and impact suddenly and slowly, require priority implementation of a programme focusing on the systematic creation and improvement of impact scenarios – both for Natural and Climate Change related risks – by means of land, airborne, spaceborne and synthetic data and models. A multi-dimensional (space and time) geographical
base of data arising from such blend of activities, should be exploited and updated on an annual basis, or at a refresh frequency consistent with the realistic rate of change in the urban cartography.

As far as the seismic risk sector is concerned, either in relation to large magnitudes seismic shaking, or constraining the kinematics of active faults, it is paramount that INM finds a way of assuring capacity (on a constant basis and adhering to the basic ground rules) when it comes to the acquisition, the classification, modelling and interpretation of seismic data, as well as an adequate level of communication. As is the case in geophysical services in most countries, the lack of clarity in technical information spoils the eventuality of successful self-protection, and calls for a significant improvement in the efficiency of communication addressed to the general public.

C. COMMUNICATION

Experience proves that it is not necessary to evoke large and recent land disasters in order to raise a "useful" awareness of risk and the "right" reflexes for auto-protection, because these events should be seen as generic and external, as they concern communities far away and of very different cultures. For example, the Tunisian population's limited vision of exposure to seismic risk – and the inherent, poor respect of norms and plans - is easily explained by the time elapsed from the last major seismic event (the 18th century). Following the results of the analysis of risk and needs for communication, it appears to be important that all technical measures be accompanied by a national awareness raising programme, dealing with the development of auto-protection, organised and scaled on the individual, the family and the community levels. The programme should address all fast-acting impact risks; it should aim to fill the gap which exists between the information obtained from the geophysical surveillance systems, and the content of information capturing the attention of the vulnerable link in the chain, namely the everyday man in the street. After a preliminary analysis on the customization of communication methods and the choice of technological issues to be put in place, the programme's contents suggest that management will not necessarily lie with the sectors managing the Early Warning systems, but that it will be shared with a chosen government official and leading local level official bodies, such as City Councils, for instance.

D. FLOODS

Events over the last 50 years indicate that system resilience with regards to Tunisian national security measures must be reshaped around a general improvement especially in the three following elements:

- In order to improve emergency response - whose performance was judged unsatisfactory in each of the urban crises associated to torrential rains in 2003, 2006, 2007 and 2009 - it would be best to coordinate the management both in advance (so-called "remote protection", depending on the Office of Large Dams and the Major Hydraulic Works) - and the downstreaming management (referred to as "close protection", depending on the Office for Urban Hydraulics), by creating a unique and centralised surveillance network. This is expected to lead to an integrated, systematic monitoring of fluxes and excess water in urban wadis.

- Substantial reinforcement of capacity to forecast meteorological data both short and very short term (presenting sufficient warning and an acceptable level of confidence), of frequent torrential rain gaining in intensity, constituting the short term element of climate
change, should be implemented at the INM whose role has become paramount since the reorganisation of tasks in 2009.

- One suggestion is to consider re-grouping communication within the correlated surveillance and information networks, such as meteorological and hydraulic data, in order to facilitate a convergence of forecasts before any warning alerts. This would ease circular diffusion of information, making the auto-protection measures more efficient in terms of individuals and groups of individuals. In terms of Climate Change follow-up and forecast, we further observe that the whole of surveillance networks (meteorological and hydraulic, e.g.) can already acquire data useful for both climate change and very short term events, the limiting factor being that of creating a complete archive with adequate length, format and homogeneous content, for dealing with phenomena spanning over several decades.

E. IMPROVEMENT OF PREPARATION AND RESPONSE MEASURES

We have already noted that the National Office for Civil Protection is not equipped with technical and legal means powerful enough to coordinate complex urgent situations, and this coordination cannot be satisfied by an immaterial organ of superior intermediation as the National Commission - whose non-executive secretarial functions are managed by the ONPC.

This share of competence induces a temporal and material gap in the chain of commands which needs to be drawn closer. A re-classification of skills should allow a pre-alerting system to be put in place, managed on a continuous basis (in which the National commission of G.C. would not be brought together), which would alert a crisis situation totally dependant on this warning system. This clarification would be used also to allow a transparent transformation from a pre-crisis situation to a regional, inter-regional or international emergency, without interruption or modification of the chain of command. It is recommended that the organism (however old) in charge of the system:

- possesses the capacity to build catastrophe scenarios, or the capacity to use to a full extent, scenarios created by third parties (the capacity can be outsourced)
- has the capacity to create or modify thematic mapping of hazards and risks (the capacity can be outsourced)
- be able to execute and/or modify, on an autonomous basis, safeguarding measures, including evacuation zones and zones of concentrated resources (here too, capacity can be externalised)
- exploits its power to coordinate and organise regular exercises and drills simulating the response procedure to be followed in case of major natural disasters hitting the Grand Tunis area.
2. Present Situation in Morocco and Recommendations

2.1 Limitations of the Current Institutional Context

The analysis of the Moroccan system for managing the risk of natural disasters and climate change provided relatively satisfactory results. In comparison to the previous decade, the study highlighted a steady improvement in the level of national organization as well as advances in technical skills and closer, fairly well-balanced inter-disciplinary ties between the Government structure (Ministries of Interior, of Environment, of Infrastructures) involved in these issues.

As far as the management of Natural Risks is concerned, documents show that Morocco has taken due care to adapt the bulk of regulatory body and norms to its objectives. Following the restructuring of the General Directorate of Civil Protection carried out between February and March 2009, the management of emergency situations has improved its performance - according to interviewed stakeholders- with a good appreciation of the current watch and Co-ordination Committee) appear to have behaved satisfactorily. A positive example to quote is the fruitful cooperation between the National Meteorology, the Hydraulic Basin Agencies and the Civil Protection, in the preparation for, and reduction of the impact of flash floods triggered by torrential rainfalls that occurred across end-2009 and early 2010: a success likely associated to the near-linear nature of the context (a fairly well defined hydraulic basin with a few obstacles), that could not be repeated in November 2010 in Casablanca and at the city’s outskirts.

In organisational terms, it should be noted that removing the inter-ministerial overlaps of skills at the national level left a relatively simplified structure, with a coordination framework functioning rather smoothly. This shows the advantage of separating the role of high command levels, ensuring a Communication-Command-Control structure, from the technical role of the Fire Department.

The analysis of Phase 1 enabled us to identify structural and operational weaknesses that require both technical and strategic improvements. In particular, it is worth quoting the assessment on general warming in terms of change in the percentage of hot days yearly, rather than in terms of increasing temperatures. This thesis drawn from only-weather data (that would point to phenomena impacting the Country’s fragile economy, should it be confirmed over the short and the mid-term,) points to the need for quantitative evidence based on independent data to test inverse models of Climate Change and deduce impact scenarios, or at least to improve the constraints on the physical parameters of interest.

2.2 Recommendations

In the analysis of Phase 1, we defined the institutional framework in which emergency preparedness activities take place to prepare Moroccan society for the impact of Major Natural Disasters and Climate Change. We noted that these two main classes of events differ mainly in their temporal character:

- in the case of Climate Change, the fairly slow occurrence of the entire phenomena suggests action on the scale of a decade, allowing the territory of tomorrow to start being defined today through changes ranging from habitat de-densification up to the relocation of entire communities as preventive adaptive action;
in the case of Major Natural Disasters, the timing and location of events are not always foreseeable, and some exceptional events may occur at any moment: in a large, heterogeneous territory such as Morocco, preparation requires mobilizing means and involving human and financial resources that are difficult to mobilize even in high-GNP countries.

Aimed to exploit the spatial and temporal overlaps of Major Natural Disasters and Climate Change, three serial actions should be planned:

- in the short term, the focus should be on (i) the substantial improvement of the knowledge on hazards and territorial elements vulnerable to fast-impacting major Natural Risks, including (ii) the improvement of Early Warning systems and a strengthened capacity to analyze data and interpret the territory;
- in the short and the mid-term, (iii) to act for improving substantially the effectiveness of the operational response to Major Natural Disasters, while (iv) improving the scientific knowledge and the capacity to observe and model long-term hazards and vulnerabilities. These actions should accompany (v) a continued action to adapt the existing surveillance systems to the detection and monitoring of Climate Change related phenomena.

A. MAJOR NATURAL DISASTERS: IMPROVEMENT OF KNOWLEDGE AND SCENARIOS

The development of scientific knowledge and the improvement of technical knowledge of hazard sources and vulnerable elements (material and human) – and the inherent definition of a realistic range of impact scenarios for major natural disasters in terms of meteorological, hydraulic, seismic/tsunami components – is critical for improving the capacity to protect life and property.

This activity is currently in the hands of technical and scientific institutions autonomous and external to the strict ministerial limits, namely:

- for Meteorological issues, Maroc Météo, an “Independently Managed National Service” operating under the heading and of the Secretary of State for Water and Environment (SEEE - Secrétariat d’État à l’Eau et à l’Environnement);
- for Hydraulic issues (surveillance, modelling, forecasting, communication) the Hydraulic Basin Agencies, equally lying under the SEEE. The reference stakeholder in the study was the Bouregreg Basin Agency, one of the first such Agencies created in 2000.
- for surveillance and research on Seismic and Tsunamigenic issues, the National Institute of Geophysics (ING) of the National Scientific and Technological Center (CNRST).

In an update of skills and tasks a further, substantial technical support should be provided by another autonomous Entity:

- the Royal Centre for Spatial Teledetection (CRTS), currently more involved in general mapping (land use, agriculture, diverse minor risks), could execute more general tasks in support to territorial information services and emergency management (as done by most of Space Agencies worldwide since early this century).
The actions recommended in the present report are part of an effort that may be defined as "the reduction of the impact of Major Natural Disasters through the improvement of preparedness and Early Warning". Such effort is generally scaled onto a national level. At the level of the areas covered by the study, this involves the promotion of:

- further strengthening of the capacity in acquisition, storage, processing and analysis of seismic data, with special attention to the seismic resilience of public and strategic structures, and the characterization of possible local tsunamigenic sources;
- the development and the adoption of plans and measures for the urban development incorporating the mitigation of major, natural, Climate Change related risks (based on the development of a range of statistically sound Air-Water-Land impact scenarios, focusing on time horizons compatible with planned or forecasted urban developments);
- the strengthening of flood Monitoring and Early Warning systems through the technical and operational integration of existing networks of Hydraulic Basin Agencies, and the meteorological observation-and-forecast routines;
- the development of appropriate scientific and technological capacity in the zoning of hydraulic vulnerabilities and the routine development of land emergence or coastal flooding scenarios;
- preparation for the self-protection of individuals and small communities against all risks involving rapidly developing phenomena as a preliminary step in the establishment of, Early Warning procedures for direct Public Warning, at the straightforward benefit of population;
- the implementation of a specific Early Public Warning of fast-impacting Hydraulic events, meant to allow self-protection of individuals and small communities against Flash-floods, Tsunamis, and Storm surges, and to mitigate the vulnerability feeling of coastal populations worldwide following major disasters in the coastal Indian Ocean (2004) and in Japan (2011).

**Institutional Coordination**

In consideration of the above the points, there is no doubt that the powers to co-ordinate Water-related affairs, Meteorology and Climatology stay with the Secretary of State for the Water and the Environment (SEEEE), under the Ministry of Energy, Mining, Water and Environment, whose ample mandates cover Research, Development, Planning, and Monitoring.

Relevant interactions are those with the (a) Ministry of Housing, Urban Planning and Land Development – and in particular the “Secrétariat d'État à l'Habitat”, covering the field of seismic engineering – (b) its local branches “Inspections Régionales” delegated to the planning or urban spaces, (c) the Ministry of Public Works and Transports, with (d) its Directorates General of “Situations à Haut Risque” and “Ports et Domaine Publique Maritime”.

The main actor in the management of emergency situations, the Directorate General of Civil Protection of the Ministry of the Interior, operates both as the operational coordinator of emergencies, and the End-User of the monitoring and Early-Warning issues referred to above.
B. IMPROVEMENT OF THE EFFECTIVENESS OF THE OPERATIONAL RESPONSE

By the law, the operational “response” to events including national or major regional emergencies lies under the General Directorate of Civil Protection, under the heading of the Surveillance and Coordination Center (CVC) of the Ministry of the Interior. This general scheme was extended to the operations of local entities, either through independent actions pre-authorized by the CVC, or actions supervised by the CVC itself, if appropriate and possible.

The improvement of this mechanism must focus both on the quality and quantity of resources for preparedness, and on the timeliness and quality of response. Before any decentralization of tasks – highly desirable in consideration of size, orography and demographic distribution of the country – it is crucial that the actors identified at the central level or at the level of the provinces (Wilayas) have at their disposal: (i) a range of provisional impact and damage extent scenarios, and (ii) the real-time control of the status and distribution of critical parameters, aimed to (iii) allow decisions according to the forecasted evolution of the actual event, and the availability and areal distribution of resources.

The appreciable efforts in terms of anticipating event scenarios developed by the Civil Protection – assisted by Maroc Météo – in response, or in forecasting the floods engendered by the torrential rains of 2010 and 2011, unfortunately did not succeed in preventing either systematically, or at the desired level, either damage or casualties. It is therefore recommended to review the Command Chain in order to verify which changes would allow improving more the effectiveness of response.

The Command and Control procedures adopted in Morocco, focuses on a near-vertical organizational response, seen as a set of emergency actions necessary to respond to the event. This process is shared by nearly all North African countries, and includes neither the capacity to cope with heterogeneous scenarios (as many scenarios as many combinations of major natural disaster in the Moroccan territories) nor the capacity to interact autonomously with the data of monitoring networks without the intermediation of the CVC cited above.

This (though fundamental) choice is not dealt with here: nonetheless, in order to increase the response timeliness and effectiveness of the Civil Protection mechanism, it seems appropriate to suggest establishing a permanent shortcut between the Early Warning systems as above and the DGPC, aimed to minimize the decision delay, automatically, without waiting for the decision chain (up to the CVC and back) to go through its paces.

This implies the availability of multi-disciplinary technical skills in the DGPC, in a sufficient quantity to guarantee the immediate operational choice in situations of low to medium gravity, without weighing down the structure but without short-circuiting the Surveillance and Coordination Committee. The proposed scheme does not require larger autonomy or decentralization with respect to the current national schemes, but it may apply both at the central and at the regional/provincial level, benefitting of the results of the technical analysis highlighted above.

**Needs associated to the management of Floods**

Twelve of the technical forms presented in Chapter 5 point to the control of different types of floods, and two to the management of water resources, revealing a twofold framework that focuses on the management of both Water and Excess water. Again, there mainly are two actors:
for policy making: the Secrétariat d’État à l’Eau et à l’Environnement, also benefits from the advice of the Conseil Supérieur de l’Eau et du Climat, a forum created to debate the fundamental orientations in terms of water resource management;

for the hydraulic protection of the Moroccan territory: the Agencies of Hydraulic Basin (ABH), benefitting of an overall satisfactory autonomy – both administrative and operational. Such autonomy seems to act, and have acted as the key-element for the acknowledged good performance of the ABH system in general.

Without any doubt, the activities proposed to improve the performance of the Moroccan protection system as a whole, require a significant investment in technology. It is therefore straightforward to state that this will involve a major, multi-disciplinary effort in advanced training, that normally outlies the responsibility of the institutional entities quoted above and is expected to demand an adequate support in terms of external knowledges and know-hows.

C. CLIMATE CHANGE AND LONG TERM VULNERABILITIES

The improvement of scientific knowledge, the integration of analyses, the development of the capacity to model hazards and make projections on an analytic and geographic basis- to assess possible long term vulnerabilities - suggest a process of adaptation of the existing monitoring systems to the and the monitoring of Climate Change related phenomena.

The capacity to detect significant changes in known physical parameters, and to model and predict their evolutions comfortably in advance, relies entirely on the capacity to acquire, process, and analyze long-lasting, dense, heterogeneous and multi-parameter datasets. For this to be possible, it is mandatory that the continuity of the whole of main databases be ensured at a level of quality, allowing corrective measures to be taken in time with respect to a wide fan of slow-developing phenomena (among others: the fractional increase of temperatures, the slow rise of eustatic levels, etc.).

Five technical sheets presented here, focus directly or indirectly on the submersion of coastal areas, and the protection of the coast against long-term phenomena. Yet rising sea level scenarios take place over the long term, which requires an institutional continuity that can only be guaranteed by independent bodies – such as the Agences de Bassin Hydraulique or the Institut National de Géophysique of CNRST.

Institutional Coordination

It appears appropriate that the overall coordination remain with the Secrétariat d’État à l’Eau et à l’Environnement (SEEE), as the focal point of the United Nations Framework Convention on Climate Change (Convention Cadre des Nations Unies sur le Changement Climatique, CCNUCC) and of the International Strategy for the Reduction of the Impact of Climate Change and Global Warming (Stratégie Internationale de la Réduction d’Impact des Changements Climatiques et du Réchauffement Global).

With the exception of the Directorate General of Civil Protection, and its coordinating committee CVC – and with reference only to the long-term actions – all institutional actor is expected to play a precise role in the implementation of activities to protect the Moroccan nation against a set of phenomena whose shortest-term impact timing is not expected for another 10 years.
3. Present Situation in Egypt and Recommendations

3.1 Limitations of the Current Institutional Context

Egypt is slowly moving from a reactive approach of managing disasters and climate change, which relies primarily on emergency response, to a more pro-active approach of risk reduction and preparedness. Till now, the Egyptian government has focused on post-disaster relief and rehabilitation activities, as evident in the rescue and relief efforts following past disasters. Less attention to adopting prevention measures against major natural risks may be because of relatively moderate impacts of past disasters in the country. However, recent disaster events, such as Cairo’s Moqattam September 2008 landslide (rockfall and slope collapse leading to the loss of 107 lives) burying the Duweiqa informal settlement, points to rising vulnerability resulting from poorly constructed and maintained buildings and infrastructure, settlement of population in hazard prone areas, lack of infrastructure to ease rescue efforts, absence of Early Warning system and inter-agency protocols in case of crisis. Slow-onset disasters such as water scarcity and other risks resulting from climate change may further aggravate the existing vulnerability.

From 2000 onwards, the national government passed several decrees to establish the legal and institutional basis for disaster and risk management, and climate change adaptation. The current structure for disaster management and response follows a highly centralized organizational set up, with the Information and Decision Support Center (IDSC), under the Egyptian Cabinet, as national coordinator for Crisis Management and Disaster Risk Reduction, and the Civil Protection Administration, the Ministry of Interior, acting as the operational arm. The IDSC plays a pivotal role in the coordination of disaster-related crises, and more recently in managing risks related to disasters (in 2005 after Egypt signed the Hyogo Framework of Action in 2005) and climate change. Other scientific and technical entities active in the field of disaster and climate change risk assessments are the Egyptian Meteorological Authority and the Egyptian National Seismic Network (ENSN).

While the near-vertical geometry of the Egyptian State’s structure minimizes horizontal overlap between the tasks and the duties of two or more neighboring entities, the local government appears to have limited resources and decision making power. For example, the Physical Planning Center for Alexandria Region is entrusted with the preparation of urban master plans, but their validation and issuing still remain with the central GOPP. The Civil Protection Administration plays an important role in emergency response with a focus on rescue and relief operations, and training of personnel in crisis management. At a local level, the Decree of the Minister of Interior gave the authority to establish regional Civil Protection units under the leadership of the Governor to respond to emergencies, with operational equipments and trained personnel for rescue and relief operations. Other national agencies that are involved in natural risk management at local scale in Alexandria are the Ministry of State for Environmental Affairs Agency, EEAA: Alexandria Regional Branch Office, the Coastal Protection Authority, the Alexandria Sanitary Drainage Company, and the Lake Maryut Management Authority. These agencies’ mission is to enforce laws, develop erosion, flooding, and marine submersion control projects.

Local authorities, which were interviewed in Alexandria within the framework of the present study, called for adopting a more decentralized approach in decision making, and for widening the mandate of the Governorate and local institutions in disaster management.
Insufficient involvement of the Environmental Management Unit, lack of financial resources, lack of inter-authority coordination (no regular meetings held), and severe deficiency in law enforcement were also considered to be the most urgent faults to repair.

A case study of 2010 Sinai flash-flood was undertaken as a part of this study. This case study is comparable to 1972, 1979, 1991 and 1998 floods in Alexandria. The case study highlights the need for significant and continued investments in Early Warning and communication, together with a strong focus on emergency response needs. Overall, although there has been some progress in multi-agency coordination in the last decade, further improvements are required in timeliness, coordination, and effectiveness of the national system of monitoring and Early Warning. It is recommended that multiscale preparedness and response may still rely upon the present system(s), with the provision of a few key technical improvements targeting efficiency and robustness.

Phase-1 analysis allowed stating that weakness points in the efficiency of the Egyptian framework are (a) a redundancy in the decision tree, with (b) the technical decision being mostly disconnected from the (c) operational decision that is taken in the Operation Room. Another point is that (d) even though Governorates are provided with their own structure, there is little automation in the action as the decision is dependent on an information that is usually available at a broader scale in national networks.

It was found essential, therefore, to stress the need of improving the observation capacity in terms of quality, quantity and timeliness of monitoring. This is expected to reflect, in turn, into an improved capacity of modeling the observables and transforming them into forecasts (a capacity not lacking at all in Egypt), the Project team sees two steps as above, are the way to effectively come into full control of the territorial situation, as to give rise to the implementation of a full C³I system (Command, Control, Communication, Information).

In consideration of the geographical stretch of hazards jeopardizing the Alexandria area, it is expected that slow-impacting hazards – as the Climate Change driven ones – are accurately monitored and evaluated on spot, whereas the distant or distributed sources of fast-impacting events (earthquakes, tsunamis, meteorological extremes) are relayed from a broader, national/international observation-and-modeling network. This should enable the Governorate to take only operational decisions, on the grounds of best available expertise located abroad and timely homed, with an expected, significant improvement in the action quality and timeliness.

The possible financial scheme (insurance), searched for in the sake of ensuring sustainability of the costly risk mitigation actions investigated and/or proposed in this project, could be enacted and run only if sufficient means for evaluating (first) and controlling the risk evolution with time (second) will be available, running and reliable.

3.2 Recommendations

A. GENERAL OBSERVATIONS

The overall impact of natural risks (earthquakes, floods, landslides and storms) on Egypt in the last 60 years is well figured out by the number of casualties that ranges between 1400 and 1500. With respect to most of the Mediterranean, African and Middle East countries, these figures point to a moderate-hazard region, whose top natural disasters impact is associated to the 1992, 5.3 Magnitude, Dahshour earthquake. Poverty has a role in this picture, as slightly less than 50% of the above casualty tribute comes from damage triggered by that earthquake.
on poorly maintained buildings: and another 12% comes from two relatively small rockfalls that buried two urban “informal settlements” in 1993 (Al-Zabalyn) and 2008 (Moqattam).

The study area of Alexandria suffered from the 1955 earthquake only, that was responsible for a few tens of casualties. Then, no comparison is possible between recent times and late-Roman and Middle-Age, with their deadly tsunamis of 365 and 1303, triggered by major earthquakes in the Hellenic Arc and the Alexandria-facing Crete, respectively. The over 900 years elapsed between those large events - and the ca. 700 elapsed from the great earthquake of 1303 to date - testify of a major, slow-building hazard that has to be taken in due account when redrawing the urban asset of Alexandria, and attempting at securing its historical heritage and its future. On account of this evidence, all action for mitigating the whole of Major Natural Risks insisting on the Alexandria Region (a) should be projected into the mid-to-long term, and consequently (b) deal with Major Risks and Climate Changes at once.

No surprise therefore if, among the 27 technical sheets introduced earlier in the Phase 2 report, as much as 15 deal with earthquake, tsunami and coastal flooding vulnerability (Tables 10 to 25), whereas 6 deal with miscellaneous protection methods and initiatives, 2 with water management, and 3 with long-term phenomena, including Climate Change.

B. THE INSTITUTIONAL FRAMEWORK OF BENEFICIARIES

The beneficiaries of the technical work as above are the structures dealing with strategic issues and crisis management, in a suitable combination of national and regional targets. Having account for the fairly vertical arrangement of the decision chain in Egypt, they can be framed into three groups only (Coordination and Crisis Management, Strategic Sectors, Scientific and Technical Support).

1. Coordination and Emergency Management – the core of the current protection system includes Entities involved in Policy-making (the IDSC – Information and Decision Support Center), Management of operations and Coordination of response (IDSC and NCCDMRR - National Committee for Crisis Management and Disaster Risk Reduction), Emergency response (General Administration of Civil Protection). At the Governorate level the National system is duplicated, as the Governor chairs the Governorate Civil Protection Unit and mostly enacts the indications of IDSC and NCCMDRR. As a general statement it is worth observing that – in the current Egyptian system – prevention issues are typically understated with respect to response, and the system shows ready to receive preparedness inputs above all.

Overall, this «Coordination and Emergency Management» group is beneficiary of works on short-to-mid term risk and vulnerability, referred to in particular by the technical notes on Multiple Risk Management, Ground Instability and Seismicity, and Flood Control. As stated above, however, much of the outputs – including the improved monitoring systems – should be exploited in conjunction with long-term risk issues as those on Climate Changes.

2. Strategic Sectors – include both the Environmental and the Urban Development issues. Environmental issues (including Climate Change) are dealt with and managed by the Ministry of State for the Environmental Affairs through the Egyptian Environmental Affairs Agency. Under the auspices of the National Committee on Climate Change (NCCC), EEAA enacts the Egypt’s Climate Change National Action Plan (ECCNAP) by means of its Climate Change Unit (EEAA-CCU). As it deals with the areal distribution of short-, mid- and long-term vulnerabilities at the national and the
local scales, a major strategic role is deserved to the Ministry of Housing and its General Organization for Physical Planning (GOPP), in terms of monitoring, planning and control of a sensitive issue as the Urban Development.

Overall, this «Strategic Sector» group is beneficiary of the works Climate Changes and the long-term term Hazards and Vulnerabilities, in particular those referred to in the technical notes on the Control of Coastal Erosion and Marine Submersion, and the Water Scarcity Management. However, the sector shall also benefit of part of the outputs of Multiple Risk Management and of Ground Instability and Seismicity, in particular, those related to the Integration of Climate Change Adaptation and Mitigation Measures in urban context, and those on Monitoring (more than Early Warning) Systems.

3. Scientific and Technical Support – A perspective picture of the needs in Scientific and high-level Technical work at the national and supra-national scales, led to add this small group of Entities acting – at the same time – beneficiaries of, and contributors to the activities dealt with in the Action Plan. The group includes four Entities provided with miscellaneous scientific and technical expertise, covering the national territory and carrying out scientific work alongside their technical Institutional duties:

- two independent Authorities: the NAARS - National Authority for Remote Sensing and Space Sciences, and the EMA – Egyptian Meteorological Authority
- one major Research Institute: the NRIAG - National Research Institute of Astronomy and Geophysics with its Egyptian National Seismic Network (ENSN)
- one major Non-Governmental Organization operating at the national-level, the Egyptian Red Crescent.

In consideration of the peculiar scientific problems associated to the understanding and the forecast of the dynamics of northern Egyptian shores – and the inherent impact on the protection of those heavily populated areas – the possibility of a partial involvement of the Coastal Research Institute (Co.R.I) of the National Water Resource Center (NWRC) should be explored.

In addition to its coordination and management role, the IDSC can also have a scientific and technical function through the Center for Future Studies (CFS), which can help in research work concerned with scenario building exercises and other future studies methodologies (e.g. Delphi) that can be useful in drawing plausible future scenarios for 2030, e.g.:

- in the Preventing Sea Submersion Risks action sheet different scenarios of areas that might experience sea submersion by 2030 and the potential effects and costs could be executed by the IDSC as action plan supporting research,
- and CFS can also be useful with respect to Early Warning System, in the research related to the management of flood scenarios.

C. ESTABLISHMENT OF A MONITORING AND FOLLOW-UP MECHANISM

The preparedness for natural disasters and climate change adaptation will require a solid mechanism for monitoring changes related to the urban environment and the accumulative effects of sea level rise. This action aims at establishing this mechanism within the national urban observatory (NUO) in order to:
Monitor and evaluate the effects of the climate change on the urban environment and extrapolate future trends and risks. Those future trends will assist in the accurate and continuous revision of the urban area classification based on its vulnerability to climatic change threats.

Monitor and evaluate adopted actions and policies and their effect on the adaptation to climate change.

Establish an Early Warning system against possible disasters and risks.

Provide the decision and policy makers with information on urban conditions and trends.

Coordinate with national and international Observatories and Monitoring and Evaluation (M&E) institutions in order to develop indicators and trends.

The Egyptian National Urban Observatory (NUO) is an important coordination tool among all agencies concerned with urban development processes. The NUO is affiliated to the General Organization for Physical Planning (GOPP). Its key mandate is to provide all relevant data and urban indicators to decision and policy makers responsible for preparing and formulating national urban development policies. Local Urban Observatories are now in the process of being established in each governorate. It is proposed that a mechanism for Early Warning and monitoring climate changes to be incorporated within the Local Urban Observatory (LUO) of Alexandria.

The mechanism will include:

- A set of urban and environmental indicators that describes and monitor changes in the urban environment related to climate change effects (e.g. sea level rise, seismic activities, flooding, etc.)

- A monitoring unit to follow-up progress in the implementation of mitigation and adaptation measures.

- An Early Warning system connected to other LUOs and regional observatories (Regional Arab Urban Observatory and the Global Urban Observatory).

- Provide training and capacity building for local staff involved in the LUO Alexandria.

- Prepare and circulate reports and periodic brochures for public awareness and dissemination of best practices.

- Periodically update and assess the urban vulnerability classifications based on indicators. The updated vulnerability map could add or eliminate zones based on previous trends and current measurements.

Anticipated constraints and difficulties are: weak local mechanisms for monitoring and follow-up; monitoring and follow up mechanisms will need the National Government financial support. Uncertainties cover: the ability of the local authority to properly supervise the Monitoring and follow-up mechanism; the availability of trained and permanent staff for implementing climate change adaptation measures within the local urban observatory; the lack of accurate data sources in some urban sectors and uncertainties regarding climate change magnitude of effects. The contracting authorities would be the Alexandria Governorate, the GOPP – National Urban Observatory, and the NARSS – National Authority for Remote Sensing and Space Sciences.
1. **Introductory Statement**

Phase 1 and Phase 2 reports are structured along country case studies. Here the purpose is to attempt some synthesis of the various results switching to a presentation along different typologies, namely risks and adaptation measures. While it is legitimate to compare results, one must keep in mind the constraints of the chosen approach. By measuring cost and benefits from a baseline that is very site specific, comparisons can be skewed and misleading; indeed, a given measure in a same hazard context would lead to different results because of the difference in vulnerability. Measure efficiency as measured accounts for planning as it currently stands; the reason for that choice was to orient the study towards decision making rather than sole technical analysis. Another word of caution is needed before commenting the results: the perimeter varies between cities, since they don’t face the same risks, but also because quantification could not be achieved uniformly throughout the different sites. For a thorough understanding of the meaning of figures, the reader is kindly invited to refer to Phase 1 and 2 reports where much greater level of details is provided on the methodology used and on calculations performed.

2. **Damage Base**

In Phase 1 the baseline scenarios are unfold for the sites of Tunis, Casablanca and Bouregreg valley, and Alexandria. The graphics below compares the cumulated damage base in the three urban areas in absolute terms (billion Euros) and relative ones (in percentage of the 2010 GDP respectively of each site)\(^4\):

**Figure 24**: Cumulated damage base in the three urban areas in absolute terms (billion Euros) and relative ones (in percentage of the 2010 GDP respectively of each site)

\(^4\) In the reports a sensitivity analysis has proven relevant for the represented values. In order however not to overload the graphs here we use the value of higher confidence only (\(x^* = 7\%\), cf. phase II report).
This represents the cumulative loss of disasters (when possible to quantify) in a “Business as Usual” scenario, including negative impacts of climate change as forecasted. The potential losses are big enough to bring this issue to the highest level urban planning decision makers. It is interesting to see that the higher risk area – Tunis, see array below – somehow ends up with the smaller damage base. Although several explanations should be factored to fully account for that, certainly the existing awareness and planning made by the Tunisian authorities is to be credited here. Indeed, that lowers significantly the damage base.

Figure 25: Comparative analysis of urban risks in the four sites

<table>
<thead>
<tr>
<th>Urban Risks</th>
<th>Alexandria</th>
<th>Tunis</th>
<th>Casablanca</th>
<th>Bousreg Valley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizon</td>
<td>Current 2030</td>
<td>Current 2030</td>
<td>Current</td>
<td>Current 2030</td>
</tr>
<tr>
<td>Seismicity/ground instability</td>
<td></td>
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<td></td>
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<tr>
<td>Tsunami/Marine submersion</td>
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<tr>
<td>Coastal Erosion</td>
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<td>Flooding</td>
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<tr>
<td>Water Scarcity</td>
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</tr>
</tbody>
</table>

Very High | High | Medium | Low | Very Low

It would be inappropriate though to conclude that such risk planning does not occur at all in the two other sites. For example in Casablanca, the very high value of real estate tends to increase the “risk bill” but also, mechanically, it makes adaptation measures more profitable (cf. the next subsection). The case of Alexandria is somehow worrying, in the sense that the perimeter of quantified risk is from far the smallest (earthquake risk mostly) but we still end up with a pretty serious at risk base.

Overall - comparison with Alexandria is difficult since the geologic risk only could be quantified - it seems that the urban flooding represents the greater share of potential damages. The relatively small share of coastal risk in Morocco can be surprising knowing the high value of real estate. This is to account for current coastal planning where most of the coastal risk areas are either protected or prohibited from building.

Figure 26: Share of potential damage by risk category for Tunis and Casablanca

Tunis only has proven high vulnerability to climate change (CC represents some 20% of total losses).
3. Adaptation Options Outlook

3.1 Tunis

The total budget for the works programme related to the resilience and adaptation action plan is estimated at TND 654 million. This is a minimum estimate for the initial studies and investments; it was not possible to establish some costs. The action plan could extend over 10 to 15 years, with the first investment tranche of half of the overall budget to be scheduled in the short term (less than five years). The majority of the financing required in the short term is earmarked for flood control measures for the Lower City (Basse Ville) area and Bardo-Gueriana.

Based on the assessment of the cost of natural disasters and climate change to 2030 completed as part of Phase 1, a cost-benefit analysis of the action plan was performed, the main findings of which are summarized in the graph below:

Figure 27: Cost-benefit analysis of the Tunis action plan

The main types of action are classified by decreasing order of efficacy and the areas represent the present value of the benefits delivered by each type of measure. The red line corresponds to a cost/benefit ratio of 1. Overall, it shows that all the investments proposed are economically justified, as the expected benefits are greater than or equal to the estimated costs.

The efficacy of the disaster warning and prevention system (institutional and urban planning measures) has been emphasized above. It is important to take a relative view of the low "return" on other types of measures. It mainly results from the prevention and protection plans put in place by the Tunisian authorities (flood protection, flood control, coastline erosion control measures), and to a relatively low threat level, relative to significant investment (e.g.: anti-seismic measures).

Taking a potential benefits base of some TND 3 billion, the total benefits amount to TND 878 million, or 29%, slightly exceeding the share of the cost accounted for by climate change alone (21%, see Phase 1). Therefore the benefits of adaptation measures more than offset the impact of climate change.

Stated in GDP terms, the present value of the benefits is 4.8% of GDP. The overall Net Present Value is TND 258 million, indicating that all of the recommended measures create economic benefits.
value. The overall efficiency ratio is relatively high (1.42) and the NPV represents 8.5% of the benefits, or 1.4% of Tunis’s current GDP. When the required investments are accounted for, the proposed adaptation measures reduce the cost of damages from TND 3 billion to TND 2,800 million, which is a reduction of some 8.5%. The estimates are conservative and these ratios may be understated.

Another factor emerges in the economic analysis: the cost of infrastructure is onerous, especially infrastructure renovation costs. Therefore the focus is primarily on new infrastructure and on controlling current and future urban development. The TND invested in this area is marginally more cost effective than in the ‘old city’, but there is also a very significant social and cultural value of the historical center, which alone justifies the investment in protection infrastructure.

### 3.2 Casablanca

As for Tunis, it shows that most of the investments proposed are economically justified, as the expected benefits are greater than or equal to the estimated costs. The efficacy of the disaster warning and prevention system (institutional and urban planning measures) has been already emphasized. The protection of Mohammedia against flood or marine submersion also shows very good Benefit/Cost ratio. It is important to take a relative view of the low "return" on other types of measures, such as erosion control. Indeed, the present study does not allow determining the economic opportunity of the measures in the absolute, but compared to a reference situation.

Let us note the high uncertainties regarding the collective measures for flood management (see the dotted line box in the graph).
Taking a potential benefits base of some DH 32 billion, the total benefits amount to DH 10,387 million, or 32%. Stated in GDP terms, the present value of the benefits is 6.2% of GDP. The overall Net Present Value is DH 5,645 million, indicating that all of the recommended measures create economic value. The overall efficiency ratio is high (2.21) and the NPV represents 54% of the benefits, or 3.4% of Greater Casablanca's current GDP. When the required investments are accounted for, the proposed adaptation measures reduce the cost of damages from DH 32 billion to DH 26 billion, which is a reduction of some 17.6%. The estimates are conservative and these ratios may be understated.

Based on these results, new opportunities for investments in adaptation measures seem relevant. Their average rate of return, and above all the exceptional return of some measures call for quick interventions.

### 3.3 Alexandria

The Phase 2 report includes an economic valuation of the recommended remedial adaptation actions against the costs of the impact of climate change and natural disasters. However, due to the lack of data, the economic analysis focuses on three main topics: discounting, cumulative seismic damage and evaluation of the proposed adaptation option, and the cumulative damage of climate change on the health sector.

Discounting is a fundamental yet difficult part of the economic analysis, especially as far as general interest is concerned, over the considered time range. The framework developed is applied to earthquake adaptation and the cumulative damage to health by climate change. It allows refining the calculation of the cumulative damage of quantified disasters proposed in phase 1, ending up with a total amount of 18,000 M EGP or 20% of the current GDP of the city over a 40-year period for earthquake activity only.

The earthquake adaptation option proved not to be economically viable in the framework developed, mainly because the level of hazard is rather low. The cumulative damage to health slightly exceeds 3,000 M EGP over 40 years. However, the study scope does not encompass health adaptation options hence it is not possible to calculate direct benefits of dedicated health options.

It is somehow difficult to develop a point of view on the non-quantified assessment that encompasses all other hazards under consideration. It is tempting to extend or adapt what could be said with more certainty on the other sites of the study (Tunis and Casablanca). We shall however remain prudent in this attempt, since the results are built upon a baseline that is particular to each site. Still, without prejudging the results of more focused studies on Alexandria, we can set out some of the lessons learned that we think might be relevant to Alexandria as well. Indeed, when some adaptation options have shown a very high level of economic efficiency on the other two sites, it can be extrapolated that the result might also hold for the somewhat similar context of Alexandria.

### 3.4 Comparative Analysis

The economic efficiency of economic measures was captured through the use of the benefit - costs ratio (B/C), comparing discounted values over time of avoided damages against implementation costs. As B/C is greater than 1, economic efficiency is satisfied (cf. Phase 2 report for further discussion on that indicator and its interpretation). The chart below shows the B/C of different measures, for the Tunisian and Moroccan sites.
Globally, efficiency is greater in Casablanca than in Tunis. It means that more pressing investments are needed, or that there seems to be more room for profitable investment in disaster management in Casablanca than in Tunis.

Interestingly, and despite the different values of the two sites, the ranking among options remains consistent somehow. The early warning system appears to be highly profitable in both cases, with very high B/C. Then coastal management and anti-flood parcel measures are also profitable in both cases, with B/C big enough to secure a profitable investment. We should however point out that B/C of this type greatly varies spatially, even on a single site. The B/C figures in the chart are derived from a weighted average. Collective anti-flood measures are still profitable even though cost nearly equals benefits in that case. Let us recall that this measure melts structural and important investments with more global measures such as integrated land management that tends to be very profitable in terms of buffering, but really more subtle to evaluate in terms of costs, that seems to be expressed mostly as loss of real estate opportunities. Last anti-seismic measures efficiency really depends on the geological context, which is not similar from one site to the other. In Alexandria for example, we are far from economic efficiency as B/C is about 2% only…

This result contrasts with the Tunis case where B/C was of 1.1. The two following points can account for this difference:

- Seismicity level is lower in Alexandria (less hazard);
- In Tunis it was possible to account for higher subsidence effects giving more momentum to a given seismic event, which in turn increases the base for avoided damages.

Overall this difference in risk translates to a very low impact compared to required investment. Still, these figures talk globally and averagely and it might well be that a more detailed spatial analysis identifies areas of strong discrepancies where economic efficiency of investment is much higher. Last, approaches with Average Annual Costs (AAC) used here might not be entirely relevant in case of extreme events.
Efficiency is a key indicator but it is also important to figure out what overall benefit each of the proposed measures generates. Indeed, a given measure can be very efficient but act only on a small base of damage, hence with overall limited “leverage”. The chart below shows the Net Present Value (NPV) of each adaptation options, which precisely accounts for that matter.

Figure 30: Net present value by risk category for Tunis and Casablanca

* Anti-flood collective measures include both urban drainage infrastructures and integrated water management planning (cf. Phase 2 report).

Interestingly, we have in this chart a lot in common with the foregoing one: (i) the ranking on both sites are consistent and (ii) Casablanca gets higher values. The ranking is even the same as before except that coastal management and collective anti-flood measures have been swapped.

It confirms the utmost importance of early warning systems: their efficiency is such that even with a somehow reduced base, the overall result remains very significant. Coastal management proves to be also very efficient but finally “leveraging” on a rather small base, making the overall effect not so significant compared to other measures. The interesting case is the collective anti-flood measures: it just passes the “efficiency test” with a B/C slightly above 1, but the impact comes second, simply because the base of damages is huge. Hence despite limited economic efficiency, urban drainage infrastructures but also integrated planning comes on the top of the agenda when dealing with disaster management which after all is not a big surprise. Anti-seismic measures have in this context limited leverage compared to other disasters.
4. Conclusion

The economic approach tends to prove here that the major driver of risk remains vulnerability rather than hazard. It can be interpreted as good news somehow, since planners can have an impact on it, which is obviously less the case with hazard, even though mitigation measures are likely to limit climate change effects, but that works globally and is hence out of hands of local decision makers. In any case, even though it tends to worsen the situation and increase the disaster bill, climate change does not seem in this context to be the most significant driver at all. In the worst case studied – Tunis – it would represent some 20% of the overall costs under a business as usual scenario. Vulnerability evolution however, resulting from human dynamics, is considerably affecting the urban fabric, by extension of coverage, sprawling and densification as well.

Unsurprisingly, the risks in the area tend to be highly intertwined and concentrated on water related hazards, either urban flooding, water scarcity, storm surges, etc…

Each site is specific and calls for a dedicated and thorough study; however, it seems that some overall statements can be generalized as far as adaptation options are concerned:

- **Early warning systems** are incredibly effective investments, and there is room for considerable improvement in all the three sites in this regard;

- **Collective infrastructures** are still needed, but they are very expensive; as city sprawls with time, it is important to find other means of increasing the “buffering” capacity of the city. Integrated water management, and adequate city planning can prove to be tremendously efficient in that perspective, and should therefore be on the agenda for discussion any time.

- **Parcel level measures** can have an important overall impact, even though of limited magnitude compared to collective ones; still, its efficiency is generally greater and so is its cost so it should be also considered as a priority.

- **Coastal management** also proves very efficient even though their spatial variability remains high; it imposes to downscale the coastal engineering expertise to the appropriate level. Overall however this is not where most assets are at risk.

- It is harder to draw conclusion in great generality for geologic hazard and corresponding option, especially anti seismic measures. It only appears about profitable in the Tunis area.

The next step could be to give further technical specifications on adaptation options, either to finalize choices or to start budgeting and implementing. Still, the financing question remains in the air: avoided costs do not credit any bank accounts and proposed measures do call for initial investment and O&M. That question calls upon the decision makers priorities, finance availability and capacity to service a debt. **Thorough public finance and project finance analysis are therefore requested to go ahead.**
Chapter 7 – Interactions with Stakeholders

As pointed out in introduction (Chapter 1), one of the three main objectives of the study was disseminating the study results and engaging stakeholders in related decision-making through: a) interaction with the national and local counterparts that have the responsibility for the management and development of the four urban locations; b) taking part in national and regional dissemination events organized by counterparts, by the World Bank, with the collaboration of relevant agencies.

1. Interactions with National and Local Counterparts

The World Bank partners and counterparts for this study were:

- **In Morocco:**
  - At national level, the Ministry of Energy, Mines, Water and the Environment, represented by Mr. Mohamed Nbou, Director of Studies, Planning and Forecasting of the Department of the Environment to the State Secretariat for Water and the Environment.
  - Concerning the Bouregreg site, the “Agence pour l’Aménagement de la Vallée du Bouregreg” (Bouregreg Valley Development Agency), represented by Mr. Lemghari Essakl, General Manager.
  - As regards the Casablanca urban site, the Greater Casablanca Region Wilaya, represented by Mr. Mohamed Halab, Wali (Governor) of Casablanca and Governor of the Casablanca Prefecture.

- **In Tunisia:**
  - The Ministry of the Environment and Sustainable Development, represented by Mr. Dali Najeh, General Manager of the Environment and Quality of Life.
  - The Ministry of Development and International Cooperation, represented by Mr. Noureddine Kaabi, General Manager of Infrastructures
  - The Tunis Municipality, represented by Mr. Abbes Mohsen, Mayor of Tunis.

- **In Egypt:**
  - At the national level, the Egyptian Environmental Affairs Agency (EEAA), represented by Mr. Mohamed Farouk, Head of the Coastal Zone Department.
  - At the local level, the Governorate of Alexandria, represented by Mr. Abel Labib, Governor.
  - The Arab Academy for Science, Technology and Maritime Transport (AASTMT), with which the World Bank has set up a specific partnership as explained hereinafter.

The Project team has worked in close collaboration with these organizations during the whole study duration, for various purposes: identification of local key experts and information...
sources, access to data and facilitation of their transmission, advises and recommendations on the study content and methodological approach, review and validation of the draft reports. The Project team remained in close connection with them through regular visits, telephone calls and e-mail exchanges.

The present study also involved a certain number of local, national and even international technical agencies, which possess data that they made available to the Project team. These organizations, with highly-qualified personnel, have also been requested to comment the study results, within the framework of the introduced consultation initiative (Internet website, presentation meetings). The following organizations in particular were encountered:

- In Morocco: the “Agence du Bassin Hydraulique du Bouregreg et de la Chaouia” (Bouregreg and Chaouia Hydraulic Basin Agency), the “Agence Urbaine de Casablanca” (Casablanca Urban Agency), and the company “Lyonnaise des Eaux de Casablanca” (LYDEC)

- In Tunisia: the “Direction Générale de l’Aménagement du Territoire” (Department of Land Development), the “Direction de l’Hydraulique Urbaine” (Department of Urban Hydraulics), the “Institut National de Météorologie” (National Meteorology Institute), the “Agence de Protection et d’Aménagement du Littoral” (APAL - Coastal Protection and Planning Agency), and the “Office National de l’Assainissement” (ONAS - National Sanitation Utility)

- In Egypt: the General Organization for Physical Planning, the Physical Planning Center for the Region of Alexandria, the Coastal Research Institute, the UN International Strategy for Disaster Reduction (ISDR), and the Information and Decision Support Center (IDSC).

Two regional partners were especially committed in the technical aspects of the study: the Arab Academy for Science, Technology and Maritime Transport (Egypt) and the National Meteorological Directorate of Morocco.

- The Arab Academy for Science, Technology and Maritime Transport (AASTMT) is a regional research and learning center registered with the Arab League. The Academy includes six main colleges: maritime transport, engineering, management, computers and information technology, international transport and logistics, and economy. Its head office is based in Alexandria (Abu Quir). The Academy wished to provide its skills and expertise for the purpose of this study and thus offered the World Bank its active contribution, with its own funds, in the section of the study dedicated to the city of Alexandria. This technical and methodological contribution has been complementary to that of the Project team, and was subject to an agreement between the Bank and the Academy, signed on 20th July 2009.

- The “Direction de la Météorologie Nationale” (DMN – National Meteorological Directorate) of Morocco – or « Maroc Météo », has been contracted by Egis BCEOM International for the realization of services relating to the analysis and modeling of climate change in the four study sites. The DMN worked in close collaboration with its Egyptian and Tunisian counterparts, and in particular welcomed them in its Rabat offices. We should note that the “Direction de la Recherche de Météo France” (Météo France Research Department) has carried out the final review of the modeling operational tools and results.

The type of data requested for the study and the main technical agencies involved in each country are specified in the table hereinafter. Given the aims of the study, the data required covered a broad spectrum of investigations, from the feasibility study to the detailed engineering design.
### DATA COLLECTED FOR THE STUDY AND TECHNICAL AGENCIES INVOLVED

<table>
<thead>
<tr>
<th>Title</th>
<th>Type of data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meteorological data</strong></td>
<td>➢ Longest possible sets of daily data on the following parameters: maxi temperature, mini temperature, rainfall</td>
<td>“Institut National de Météorologie” (National Meteorology Institute)</td>
</tr>
<tr>
<td><strong>Morocco</strong></td>
<td>➢ Topographic maps, digital terrain models, bathymetric maps</td>
<td>“Maroc Météo”</td>
</tr>
<tr>
<td><strong>Egypt</strong></td>
<td>&gt; Hydrographical and hydrogeomorphological data, modifications in natural flow conditions (diversion, channeling, cover, etc.), runoff coefficients, etc.</td>
<td>Meteorological Authorities</td>
</tr>
<tr>
<td><strong>Hydrographical, hydrological and hydraulic data</strong></td>
<td>➢ Hydrographical and hydrogeomorphological data to characterize floods and the hydrological system (results from statistical analyses, intensity/duration/frequency, historical floods, etc.)</td>
<td>“Centre National de Cartographie et de Télédétection” (National Center of Cartography and Remote Sensing) AAVB (Bouregreg Valley Development Agency), ONAS (National Sanitation Utility), AUGT (Greater Tunis Urban Agency) Ministry of Agriculture</td>
</tr>
<tr>
<td></td>
<td>➢ Characteristics of the rain water and waste water networks (main sewers)</td>
<td>“Service Hydrographique des Armées” (Hydrographical Department of the Armies) (bathymetry)</td>
</tr>
<tr>
<td></td>
<td>➢ Maps of floodable areas and vulnerability and risk zoning (thus including the vulnerability) for different floods</td>
<td>ONAS (National Sanitation Utility)</td>
</tr>
<tr>
<td></td>
<td>➢ Aerial photos, flood photos (aerial and others)</td>
<td>AAVB (Bouregreg Valley Development Agency), ABHBC (Bouregreg and Chaouia Hydraulic Basin Agency), LYDEC</td>
</tr>
<tr>
<td></td>
<td>➢ Capacity of the sewers, river or channels before overflowing, critical points and probable causes of overflowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>➢ Interrelations between intense rain and high water levels (impact of water levels on flows)</td>
<td>Governorate Alexandria General Organization for Sanitation/Drainage</td>
</tr>
</tbody>
</table>
### Oceanographic data
- Long duration recordings of water levels in ports (tide gauges)
- On-site observations (coastline, ports) on the surges reached during storm periods; storm return period to which the surge may be associated; photos
- Sedimentary maps of flat of bottom
- Map and characteristics of the maritime protection structures
- Old and recent land registry maps to enable coastal developments to be measured
- Statistical studies of directional waves and storm surges (height, amplitude, path, wind speed, etc.)
- Aerial photographs of the coastline with space-time sufficiently high to become free from the tidal effect

### Water resources and hydrogeological data
- Hydrological and meteorological data to characterize drought (rainfall levels, runoff coefficient, duration of the drought, etc.)
- Data on all supply sources, needs (changes in the population and sample-taking), past and current uses, development forecasts concerning needs and scenarios for needs/resource adequacy (with numbering)
- Data on losses from the distribution networks
- Hydrogeological data: characterization of water tables and their covers, pressures, vulnerability, possible salinization

### Seismic and geological data
- Map of natural risks
- Seismotectonic map
- Geological maps
- Geological cross-sections and log
- Geotechnical (land movements) and technological (dams) risks

### APAL (Coastal Protection and Planning Agency), INSTM (National Institute of Marine Science and Technology), ONAS (National Sanitation Utility)
“Direction Générale des Services Maritimes” (Department for Shipping Services)
Port Authorities
Land Registry (land registry office)
“Service Hydrographique des Armées” (Hydrographical Department of the Armies)

### AAVB (Bouregreg Valley Development Agency), Ministry of Development

### Coastal Research Institute
Coastal Protection Authority
AASTMT
Weather Authorities
Municipal authorities
Ministry of Transport (Navigation)

### Department of Water Resources
Specific studies

### AAVB (Bouregreg Valley Development Agency), ABHBC (Bouregreg and Chaouia Hydraulic Basin Agency), LYDEC

### Authority of the Nile
Ministry of Water Resources
Alexandria Water Supply Company


### AAVB (Bouregreg Valley Development Agency), SEEE

### Cairo University (Dr El Sayed) and specialized institutes
Two international organizations also took an active part in the study: the European Space Agency (ESA), and the Marseille Center for Mediterranean Integration (CMI).

- The European Space Agency (ESA) and the World Bank agreed on the implementation of a pilot project using satellite imagery within the framework of the study. This application has been carried out through the Earth Observation Market Development program, directed by the European Space Research Institute. This application may have involved multiple issues, such as: subsidence phenomena, coastal erosion, storm surges, water resources, urban thermal imaging, air quality, land use and critical infrastructure mapping, and urban flooding. The Project team developed close contacts with the ESA in order to determine the type of satellite imagery application and the test area for this application. It was finally agreed that the application would focus on ground motion measurement and analysis, using radar interferometry techniques. Two specialized consultants were selected: Tele-Rilevamento Europa (TRE), which performed this survey on Greater Tunis, and ALTAMIRA Information, which conducted the survey on Greater Alexandria. Their work allowed determining with relatively high accuracy (especially for Tunis) the subsidence phenomena in both cities.

- The Marseille Center for Mediterranean Integration (CMI) strives to facilitate access to best knowledge, enhance sustainable development and converge policies towards greater integration. It does so by creating opportunities for leaders in government, civil society, academia, and business to generate, integrate, share, and apply policy-relevant knowledge and analysis. CMI provides a platform for the formation of communities of practice focused on the Mediterranean region’s core development issues. CMI collaborated in the stakeholder workshops in Alexandria, Tunis and Casablanca as the study progressed, and organized and hosted a concluding regional conference in Marseille May 30-31, 2011 to bring together decision-makers and urban experts to discuss the findings and the actions the three countries might now take to lower their risks (see also next section).

2. National and Regional Dissemination

Dissemination was performed through two kinds of tools: a dedicated Internet site and several workshops.

2.1 The Project Website

Egis BCEOM International has developed a website dedicated to this project. The project website eased the exchange of information between the various project stakeholders and ensure a permanent access to the latest information related to the project.

Its address is: [http://www.egis-bceominternational.com/pbm/](http://www.egis-bceominternational.com/pbm/)

The homepage is presented below. Access to the site is bilingual French-English. The project website functioned as a portal for external communication.
The main purpose of this web-based project portal is to facilitate the exchange of information between the various project stakeholders and ensure a permanent access to the latest information related to the project.

This project, financed by the World Bank and other partners, aims to:

- assess the climate change and natural disaster vulnerabilities of 4 urban areas in North Africa: Alexandria (Egypt), Tunis (Tunisia), Casablanca and Bourgogne Valley (Morocco).
- formulate related action plans to improve their adaptation to climate change and preparedness to natural disasters.

The portal was structured in such a way that relevant information could easily be accessed to the public:

- “Project ToRs” give access to the project Terms of References
- “Project stakeholders” provide a short presentation of each project stakeholder
- “Information exchange” give secure access to selected stakeholders to a platform for heavy data exchange
- “Forum” provide access to a discussion forum to exchange on specific topics
- “Project outputs” give access to the latest project outputs (report, training, etc.)
- “Library” give access to the project bibliography
- “Contact” provide contact details of all the project stakeholders
2.2 Workshops and Presentations

The Project team took part in national and regional dissemination events organized by counterparts, by the World Bank, with the collaboration of other relevant agencies:

- Local workshops held in the three countries at the end of Phase 1
- Local meetings held in the three countries at the end of Phase 2
- A final Regional Workshop on the vulnerability of coastal cities in North Africa

These events were aiming to: (i) facilitate the study progress and the participation of all stakeholders, discussion and appropriation of the results of each study phase; (ii) and information share with other North-African cities experiencing the same issues.

A. INTERNATIONAL WORKSHOP AND SYMPOSIUM OF MARSEILLE

From June 27 to 30, 2009, two international events were held at the “Palais du Pharo” in Marseille (France), to which all the World Bank partners, involved in this study, were invited:

- The “Mediterranean, Climate and Cities” research and exchange workshop, organized by the “Caisse des Dépôts”, the ISTED, the World Bank, “Marseille Provence Métropole”, the “Ville de Marseille et Euroméditerranée” (City of Marseille and EuroMediterranean Area), on June 27 and 28, 2009. Among the organizers of this workshop, we should mention:
  - Prof. Mohamed El Raey, of the AASTMT (Egypt), co-organizer of Round Table 1 on the Vulnerability of the Region’s Cities in view of Climate Change,
  - Dr. Habib Ben Moussa, of the APAL (Tunisia), co-organizer of Round Table 3 on Economic and Financial Mechanism Initiative Policies,
  - Mr. Lemghari Essakl, from the “Agence pour l’Aménagement de la Vallée du Bouregreg” (Morocco), co-organizer of Round Table 4 on Governance Policies and Plans,
  - Mr. Anthony Bigio, of the World Bank, who ended the debates of the first two round tables.
- The 5th urban research Symposium on “Cities and climate change: Responding to an urgent agenda”, organized by the World Bank, the “Agence Française de Développement” (French Development Agency), the City of Marseille, the Ministry of Ecology, Energy, Sustainable Development and Land Development, and the ADEME, from June 28 to 30, 2009. Throughout this international event, two sessions directly concerned this study:
  - The “Panel of Mediterranean Cities on the Challenge of Adaptation” organized by the Marseille Center for Mediterranean Integration on June 29, and presided by Mr. Bigio of the World Bank. Following the Workshop “Mediterranean, Climate and Cities” from June 27-28; this session gave the Mediterranean cities representatives the opportunity to meet and discuss the priorities and concerns pertaining to adapting to climate change. Mr. Ennesser, of Egis Bceom International, presented the study’s methodological approach on the Adaptability of the North African coastal
cities to climate change and natural disasters. Mr. Pierre-Philippe Mathieu, of the European Space Agency, presented possible contributions from the terrestrial satellite observations for the evaluation of the cities’ vulnerability regarding the natural risks and climate change.

- The session on “Adaptability of cities to climate change: coastal cities” of June 30, during which Mr. Bigio presented the issue and general approach of the study on the Adaptability of North African coastal cities to climate change and natural disasters.

B. PHASE 1 WORKSHOPS

In May and June 2010, the main findings of the study first phase and the main orientations for Phase 2 were discussed through three national workshops. The objectives of these seminars were to:

- a) present the preliminary results of the urban vulnerability assessment;
- b) receive the comments and clarification of national and local stakeholders;
- c) engage the stakeholders in the reflection and priority-setting for the second phase of the study, focusing on the preparation of an adaptation and resilience action plan.

The agendas of these workshops are presented below:

**May 18th, 2010 – International Centre for Technologies and Environment of Tunis**

*Opening ceremony and welcome message*

- H.E. Mr. Nadhir Hamada, Minister of Environment and Sustainable Development (MEDD)
- Mr. Ndiame Diop, Head, World Bank Tunis Office

*Issues and approaches*

- Mr. Najeh Dali, General Manager of Environment and Quality of Life (MEDD)
- Mr. Anthony G. Bigio, Senior Urban Specialist, World Bank

*Presentation of the preliminary study findings for Greater Tunis*

- Mr. Yves Ennesser and Ion Besteliu, Egis Bceom International
- Mrs. Monique Terrier, BRGM
- Nadra and Mohsen Tounsi, SIRUS
- Mrs. Iolanda Iannicella, TRE

*Climate change, uncertainties and decision making: Mr. Stéphane Hallegatte, CIRED – Météo France*

*Objectives and methodology for the second phase of the study*

- Mr. Anthony G. Bigio, Senior Urban Specialist, World Bank
- Mr. Yves Ennesser, Team Leader, Egis Bceom International

*Brainstorming on the selection of first priority actions* (Session facilitated by Mr. Noureddine Kaabi, General Manager of Infrastructures, Ministry of Development and International Cooperation)

*Conclusions and next steps*
The workshop was attended by about 50 participants. In attendance were representatives of key local and national institutions, such as: Municipality of Tunis, General Directorate for Land Development, Directorate of Urban Hydraulics, General Directorate of Air and Maritime Services, General Directorate of Water Resources, National Institute of Meteorology, Agency for Coastal Protection and Development, Urban Planning Agency of Greater Tunis, National Office for Sanitation, National Office of Civil Protection.

June 15th and 16th, 2010 - Arab Academy for Science, Technology and Maritime Transportation – Miami Campus

- **Day 1: June 15th, 2010**

  Welcome message: H.E. Dr. Mohamed Farghali, President of the Arab Academy for Science, Technology and Maritime Transport (AASTMT)

  Opening statements:
  - Mr. Sidi M. Boubacar, Deputy Head, World Bank Cairo Office
  - Dr. Fatma Abou Shouk, Head of Environmental Management Sector, Egyptian Environmental Affairs Agency
  - H.E. Deputy Governor of Alexandria, Gen. Safaa Kamel
  - Anthony G. Bigio, Senior Urban Specialist, World Bank

  Profile of the Alexandria study (Session facilitated by Professor Mohamed El Raey, Arab Academy)
  - Tamer Abougharara, Project Team Leader, Arab Academy
  - Yves Ennesser, Project Team Leader, Egis BCEOM International
  - Dr. Mohamed El Raey, Executive Director, Arab Academy

  Results of the European Space Agency study on Land subsidence in Alexandria: Mr. Oscar Mora, Study Manager, AltaMira Information

  Vulnerability assessment findings (Session facilitated by Dr. Ali Amasha, Arab Academy)
  - Climatic Aspects, Dr Ali El-Hadidi
  - Geotechnical and seismic/tsunami Risks, Sara Hamdy
  - Coastal Erosion and submersion risks, Eng. Samar Hafez
  - Inundation, Water Resources and Needs, Dr Ola Arafat
  - Urban planning issues and sensitive urban components, Yves Ennesser and Victor Said, IAU-IDF
  - Economic valuation of climate change impacts, Yves Ennesser, Egis BCEOM
  - Institutional evaluation of natural disasters preparedness, Yves Ennesser, Egis BCEOM

  Questions and answers, & comments from participants on Phase I report findings

  Summary of first day: Dr. Mohamed El Raey, Executive Director of Regional Center for Disaster Risk Reduction, Environment Advisor of Arab Academy
**Day 2: June 16th, 2010**

*Scope of the adaptation action plan: Anthony G. Bigio, World Bank*

*Working Group*
- Urban planning (Group leaders- Victor Said and Dr. Ali Amasha)
- Coastal infrastructure protection (Group leaders- Mr. Farouk Osman and Dr. El Raey)
- Institutional preparedness (Group leader- Tamer Abougharara)

*Recommendations: Working Groups present findings*

*Next steps in the preparation of the action plan:*
- Tamer Abou Gharara, Project team leader, Arab Academy
- Yves Ennesser, Project team leader, Egis BCEOM

*Workshop summary: Professor Mohamed El Raey, Advisor, Arab Academy*

*Closing remarks: Dr. Mahmoud Mashaly, Vice President for Projects Affairs and Dean of the Integrated Simulators Complex (AASTMT)*

The seminar was attended by about 65 participants, about half of whom traveled to Alexandria from Cairo. In attendance were representatives of key local and national institutions, such as the Alexandria Governorate, the General Organization for Physical Planning, the Egyptian Environmental Affairs Agency, the Red Crescent Society, the Coastal Research Institute, the International Strategy for Disaster Risk Reduction, and numerous staff from the Arab Academy itself.

**June 22nd and 23rd, 2010 – Wilaya of Greater Casablanca**

**Day 1: June 22nd, 2010**

*Opening ceremony and welcome message*
- Mr. Mouaad Jamai, Governor, General Secretary of the Wilaya of Greater Casablanca
- Mr. Mohamed Nbou, Director of Studies, Planning and Forecasting of the Department of the Environment to the State Secretariat for Water and the Environment.
- Mr. Nadir Yacoubi, Head of Corporate Finance and Partnerships, Agency for the Development of the Bouregreg Valley
- Mr. Mats Karlsson, Manager of the Marseille Center for Mediterranean Integration (CMI)

*Climate change and Moroccan cities: issues and approaches*
- Mr. Mohamed Nbou, Director of Studies, Planning and Forecasting of the Department of the Environment to the State Secretariat for Water and the Environment.
- Mr. Anthony G. Bigio, Senior Urban Specialist, World Bank

*Presentation of the preliminary findings on the Casablanca city*
Questions and answers, & comments from participants

Presentation of the preliminary findings on the Bouregreg Valley

- Mrs. Fatima Driouech, National Meteorology Directorate
- Mr. Yves Ennesser, Egis Bceom International
- Mrs. Monique Terrier, BRGM
- Mr. Victor Said, IAU-IDF

Questions and answers, & comments from participants

Climate change, uncertainties and decision making: Mr. Stéphane Hallegatte, CIRED – Météo France

- Day 2: June 23rd, 2010

Objectives and methodology for the second phase of the study

- Mr. Anthony G. Bigio, Senior Urban Specialist, World Bank
- Mr. Yves Ennesser, Team Leader, Egis Bceom International

Working groups on the action plan (facilitated by Anthony G. Bigio, Senior Urban Specialist, World Bank)

- Urban planning
- Coastal infrastructure protection
- Institutional preparedness

Conclusions and next steps

The workshop was attended by about 50 participants. In attendance were representatives of key local and national institutions, such as: Agency of the Bouregreg-Chaouia Hydraulic Basin, Urban Agency of Casablanca, General Directorate of Civil Protection, Directorate of Ports and Maritime Public Property, State Secretary for Housing, National Office of Potable Water, LYDEC.

C. PHASE 2 PRESENTATIONS

In December 2010, a second set of events took place, in order to present and discuss the preliminary findings of the phase 2 study, i.e. recommendations for climate change adaptation and natural disaster preparedness. In each country, meetings were held with the main counterparts and working groups were organized, gathering all technical agencies involved.

December 13th and 14th, 2010 – Cairo and Alexandria

- Day 1: December 13th, 2010
  - Mr. Mohamed Farouk, General Manager of Integrated Coastal Zone Management Department, Egyptian Environmental Affairs Agency (EEAA)
Mr. Magued Osman, Chairman, Information and Decision Support Center of the Cabinet of Ministers

Mr. Mostafa Kamal Madbouly, Chairman of General Organisation for Physical Planning, and Mr. Fahima El Shahed, Undersecretary, Regional Planning Centers, GOPP

Day 2: December 14th, 2010

H.E. Mr. Adel Labib, Governor of Alexandria

Working group on the action plan, attended by about 30 participants from the following organisations: AASTMT, EEAA, UNDP, Holding Company for Sanitation and Water, Shore Protection Authority, Faculty of Science / Alexandria University, etc.

December 16th and 17th, 2010 – Rabat and Casablanca

Day 1: December 16th, 2010

Mr. Mohamed Nbou, Director of Studies, Planning and Forecasting of the Department of the Environment to the State Secretariat for Water and the Environment (SEEE)

Working group on the action plan, attended by about 35 participants from the following organisations: SEEE, High Planning Commission (Haut Commissariat au Plan), Ministry of Internal Affairs, Urban Agency of Rabat-Salé, Urban Agency of Casablanca, General Directorate of Civil Protection, LYDEC, OMRANE, etc.

Day 2: December 17th, 2010

H.E. Mr. Ouazzani, Governor, General Secretary of the Greater Casablanca Wilaya, and Mr. Youssef Bel Abbes, Director of Environment of the Greater Casablanca Wilaya

Greater Casablanca Urban Agency

Mr. Chabib Aboul Faraj, Director of Development, Agency for the Development of the Bouregreg Valley

December 20th and 21st, 2010 – Tunis

Day 1: December 20th, 2010

H.E. Mr. Nadhir Hamada, Minister of Environment and Sustainable Development (MEDD) and Mr. Ben Moussa, General Manager of Environment and Quality of Life (MEDD).

Monsieur Ghazi Ali Khadhri, Director, General Directorate for Land Development (DGAT)

Working group on the action plan, attended by about 25 participants from the following organisations: MEDD, Ministry of Cooperation, DGAT, Directorate of Urban Hydraulics, General Directorate of Air and Maritime Services, National Office for Sanitation, National Agency for Environmental Protection, etc.
• **Day 2: December 21st, 2010**
  - National Institute of Meteorology
  - National Office for Sanitation
  - Agency for Coastal Protection and Development
  - Mr. Noureddine Kaabi, General Director for Infrastructure, Ministry of Development and International Cooperation

**D. FINAL REGIONAL WORKSHOP IN MARSEILLE – MARSEILLE CENTER FOR MEDITERRANEAN INTEGRATION (CMI)**

The May 30-31 Final Regional Workshop had the following objectives: a) to allow representatives from the three cities and the project site to discuss and validate the final Adaptation and Resilience Action Plans, benefiting from regional exchanges and interactions; and b) to allow representatives of other cities and countries from the Southern Mediterranean (e.g. Algeria, Lebanon, Jordan, Syria) to be directly exposed to the methodology and results of the study in order to replicate it where needed.

This workshop can be considered as the **culmination of the interaction process** with the local stakeholders. All information related to the workshop, including the main findings is presented in **Appendix 3**.

**3. Main Findings**

The following recommendations make up a kind of project "memento". They recap the guiding principles of the action plan, resulting from the interaction with stakeholders and partners, within a strategy of effectiveness and progressiveness.

1. **Begin with a strengthening of the institutional capability** for the implementation of the action plan.
2. **Focus on the measures that prevent irreversible situations** relating to climate change, particularly represented by urban planning actions.
3. **Establish synergies between the actions that reduce the risk and adapt to climate change and the economic development investments and policies** that respond to the urgent and immediate needs of the population.
4. **Clearly differentiate between short-term measures and long-term measures.** In the short-term, until 2030, the most desirable adaptation measures are those that maximise the synergies with other political objectives like poverty reduction, competitiveness, or the conservation of natural areas.
5. **Preserve however a certain flexibility in relation to the intervention priorities**, in such a way that the financing available is taken into account.
6. **Explore new financing methods** (insurance, subsidies, taxes, etc.) and establish an **incentive-based assistance system** related to individuals and companies.
7. **Communicate about the issue of natural disasters and climate change**, with a mind to being transparent and increasing the awareness of the wider public.
## 1. APPENDIX 1: Examples of Recommendation Sheets

### 3 – Preparation and self-protection against fast-impacting phenomena (Egypt)

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present and future situation (horizon 2030) – this action is first and foremost aimed to protect the existing population. Other related sheets: 2, 4, 5, 10, 13, 18, 20</td>
<td>Strictly Institutional</td>
</tr>
</tbody>
</table>

**Aim:**
Prepare and enable exposed populations to initiate and carry out timely, autogenous, self-protection and impact mitigation actions in advance on structured responses of Civil Defence/Civil Protection bodies or their equivalent. Training based on lessons learnt by frequently striking events (flash-floods, e.g.) and on synthetic scenarios for events characterized by low to very-low repetition rates (storm surges or even tsunamis, e.g.)

**Targets / recipients:** population located in areas exposed to fast impacting phenomena (flash-floods, storm surges, tsunamis).

**Expected benefits:** self-protection is the most effective way to save human life (the individual is the first author of its protection).

**Scale:** regional

**Description**
The proposed push for autogenous protection preparedness arises from the awareness that Public Safety services cannot ensure complete and/or timely protection anytime and at any place, in particular when fast striking natural risks (with little or no alert-to-impact delay) are involved. Actions referred to are supposed to allow acting on two levels:

- on one hand, it is a matter of preparing individuals and small groups (families, or limited groups of individuals) to naturally undertake the right self-protection action in situations of imminent danger, or of disaster event in progress;
- on the other, effectiveness of self-protection requires the development of a framework in which Public monitoring-and-forecast services may circulate the information about the current risk scenario and, doing this with appropriate timeliness, allow individuals undertaking the appropriate self-protection action timely.
With the notable exception of seismic disasters, whose impact mitigation cannot rely but upon passive protection - thus, on quality, strength and overall design of the building - risks presenting a non-negligible probability of hitting the Alexandria target look limited to:

1. **Extreme meteorological events, including windstorms and storm surges.** The forecast of such, relatively fast-striking events is perfectly in the reach of modern meteorology, provided that deployed technologies and systems assisting in the meteorological watch are efficient and adequate in area density/area coverage (see Sheet 18). In principle, this is the case of Alexandria vs. the central structure of the Egyptian Meteorological Agency.

2. at a lesser level, **tsunamis** (1-hour delays between a shallow earthquake source within about 500 km, in Crete or Cyprus, and impact on the Egyptian shores). Notwithstanding the moderate hazard - only three major tsunamis are reported on the northern Egyptian shores, in the 17th Century BC and in 365 and 1303 AD - the risk is non negligible because of the combination of high vulnerability of the territory and a significant population density, with major seasonal inputs from Cairo (see Sheet 10).

The efficiency of self-protection relies upon the following **four conditions**:

- **a)** **Preparedness of weaker (more exposed) categories of citizens**, based on automated and well-addressed response to an official alert (see Box 1).

- **b)** Preparedness to be based upon **detailed escape and rescue emergency plans**, foreseeing withdrawal of population (clustered in small, manageable groups) from exposed areas. Plans are expected to identify and map the shortest and simplest way-outs from every exposed area towards the nearest safe point, based on elevation. As near-flat areas do not offer natural perspective to discriminate slightly higher from slightly lower elevations, plans should be based on Digital Elevation Models imaged through appropriate technologies, to deploy in a preliminary stage while building preparedness. See also Box 1.

- **c)** **Availability of specific alert systems, and proved efficiency of the descending alert chain.** Media of all types can be involved in the descending alert: however, on account of the type of risks dealt with, alerts would be better broadcasted on fast penetrating media. See also sheets 13 and 20.

- **d)** **Clear and immediately understandable markings** (in all needed signs and languages) pointing to routes and places to reach, and not to leave until the alert is over.

**Constraints and Difficulties**

- Current systems should be open outwards, to broadcast alerts with the most likely short-term scenarios
- Type and content of information messages to be carefully weighted as their understanding is depending on an unlinear blend of human and cultural factors, including education
- System to be run permanently on 24h/24 shifts, after launch. System performances are expected to improve with time (with number of successful and missed alerts, leading to continuous adaptive tune-up of alert thresholds)
- Needs in high-precision/high-resolution 3-D digital cartography of the whole area (including DEM, buildings infrastructure and vegetation).
- 3-D digital cartography and its changes with time are appropriate for CC-triggered, sea level rise quantitative impact forecast (yearly to two-yearly towards the horizons of 2020 et 2030, if current expectations in sea level increase gradient are met)
- Small and large group exercises are recommended
- In lack of disaster events, there is a substantial risk of collapse of the interest/attention thresholds in the
target populations. This holds specially true for infrequent events (tsunamis, e.g.)

**Uncertainties**
- Decisions on content, type and certification of alerts to broadcast

<table>
<thead>
<tr>
<th>Concerned authorities and sectors</th>
<th>Monitoring and evaluation</th>
</tr>
</thead>
</table>
| Authorities in charge: Governorate (coordination), Egyptian Environmental Affairs Agency - Alexandria Regional Branch Office, with support of Red Crescent and other NGOs (operators)  
Sectors: institutional, operational | Review of the alert thresholds at every missed alert; review of the system philosophy. |

<table>
<thead>
<tr>
<th>Cost</th>
<th>Scheduling</th>
<th>Joint mapping</th>
</tr>
</thead>
</table>
| Setting up of an early warning system: 16 Million EGP  
Information and awareness campaign: 2 Million EGP  
Preparation of rescue plans: 2 Million EGP | Launch: < 5 years | No |
Box 1: Emergency response and information plan for population

Implementation of an emergency response plan makes it possible to organise rescue operations before flooding or other forms of hazard strike. Plans usually comprise the following elements:

- Presentation and analysis of the risk in a given area: risk maps
- Organisation and modalities of activation of crisis cell
- Crisis management (in the form of information sheets):
  - organisational sheets
  - action/response sheets: intervention, early warning, evacuation, public areas and public access buildings (PAB), reception of victims, identification of affected areas, protection against theft and vandalism, communications, etc.
  - supporting sheets: crisis directory; services directory; directory of public places and public access buildings; places of shelter; population, including population at risk; plant for works, transport and communication; furniture; human resources; supply; and damage areas; etc.
- Post-crisis management – return to normal conditions
- Further development and updating of emergency plan.

Provision of preventive information to the public and raising public awareness of the flood risk are communication actions associated with the emergency plan. They may be as follows:

- campaigns to provide information to the general public: distribution of information brochures, use of the media, posters, exhibitions;
- awareness raising and training in schools and sensitive organisations;
- Display of safety instructions in public buildings (health and educational establishment, administrative offices, etc.).

Example of public information in the USA: “Emergency Preparedness and You”

1. Get a Kit: Gather emergency supplies.
   By taking time now to prepare emergency water supplies, food supplies and disaster supplies kit, you can provide for your entire family.

2. Make a Plan: Develop a Family Disaster Plan.
   Families can cope with disaster by preparing in advance and working together as a team.

3. Be Informed:
   Learn How to Shelter in Place.
   Centers for Disease Control and Prevention (CDC) and the American Red Cross have teamed up to answer common questions and provide step by step guidance you can take.

   Understand Quarantine and Isolation
   When quarantine and isolation may be called for, what they are, and how they work.

   Maintain a Healthy State of Mind.
   Tools for coping with disaster for adults, parents, children, students, and seniors.

Source: CDC Emergency Risk Communication Branch (ERCB), Division of Emergency Operations (DEO), Office of Public Health Preparedness and Response (OPHPR).
### 18 – Preventing sea submersion risks of the Alexandria coastline

<table>
<thead>
<tr>
<th>Time period</th>
<th>Sphere of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>The issue of sea submersion is not currently a concern along the Alexandria coastline except for three particular sectors. In fact, this recommendation mainly concerns future urban development (2030) in Alexandria and the current urban situation in several high-risk sectors.</td>
<td>There are seven possibilities in accordance with the possible overlaps (see position of the star)</td>
</tr>
</tbody>
</table>

**Other related sheets:** 2, 3, 4, 8, 13, 15, 19, 20

#### Aim

Limit damages from submersion to the facilities and housing located behind the beach during a storm combined with a high water level.

The present extreme tide surge leads to the partial or total submersion of the Alexandria beaches but the risk of submersion is medium to low on this coastline, except for three sectors:

- The shore between the west port and the port of Dikheila and the banks of the El Noubareya canal which opens onto this sector of the coast (the canal corresponds to the lowest area and will be severely impacted in the event of a storm).
- The El Montaza beach and the western part of the El Maamoura beach.
- The Abu Qir beach (see also Sheet 19).

For the year 2030, without any sufficiently accurate topographical data, it is not possible to conclude that an increase in the water level of 20cm will have a significant impact, compared to the limit of the highest water levels at present. The submersion situation will be slightly equivalent to the one that prevails today. Except for the three previously listed sectors, it does not seem that sea submersion during storms should affect the bordering urban areas (with the exceptional case being the lowest point from the Corniche to El Mandara, submerged in 2003 but in theory rather due to the run-up of waves on the strand phenomenon) and the facilities behind the beach. Only the beach strands are partially or totally submerged as well as the seaside facilities situated directly on the strands.

**Targets / recipients:** see above.

**Expected benefits:** avoid exposure to submersion risk and make the coastline secure.

**Scale:** regional.
Description
Generally, as it is the beach strands and the seaside facilities directly installed on the strands that will be partially or totally submerged, the measures commonly implemented to limit the submersion effect do not apply (for example: longitudinal protection structures, recession, etc.).

In the three sectors where the housing residences can be directly impacted, as they are situated on the border of the higher beach area or along the canal, and prior to any realistic proposals for submersion protection solutions, a present situation vulnerability study is to be carried out. Depending on the results of this study, measures may then be proposed, such as the following:

- Setting up a cofferdam to limit the water pressure on the fronts and windows.
- Raising water-sensitive equipment off ground level in the houses (electric sockets, refrigerator, stove, etc.).
- Moving large-scale equipment to upper storeys in public service-type buildings such as hospitals, clinics, etc.

These measures must be accompanied by the setting up of a reliable, self-sufficient and automatic submersion risk warning system (see Box 2). This could include a system of beacons at sea and on the coast measuring the hydrodynamic and meteorological parameters; the data would be processed by means of a digital modelling tool allowing the shore flooding risk to be assessed and enabling the meteorological forecasts and offshore sea states to be obtained. In the event of the alarm being given, the system could also launch a prevention and safety plan for people (see also Sheet 2).

Uncertainties
Setting up a reliable, self-sufficient and automatic warning system

Concerned authorities and sectors
- Authorities in charge: Ministry of Energy and Electricity, Ministry of Water Resources and Irrigation - National Water Research Centre, Egyptian Public Authority for Surveys (supervision), Egyptian Environmental Affairs Agency – Regional Branch, Coastal Protection Authority (coordination), Information and Decision support Centre – Centre for Future Studies, Coastal Research Institute (operator).
- Sectors: study, construction, institutional

Monitoring and evaluation
- Completion, performance and implementation of the vulnerability study.
- Efficiency of the warning system (transmission speed, data reliability).

Cost
- Vulnerability study: 120 000 EGP
- Warning system: 8 000 000 EGP
- Cofferdams: approx. 8,000 EGP / linear meter

Scheduling
- Short term (< 5 years)

Joint mapping
- Medium and high submersion risks
Box 2: Marine submersion – measurement, information, management and early warning

Independent smart buoys can be placed in the sea. These guardians of the coast – able to communicate with one another, to make and transmit real-time measurements (water depth, wind, pressure, seawall failure, etc.), and to use already available data (weather, tides, ocean swell, etc.) – are able to give advanced warning of the risk of flooding (3D mapping) and to output alert bulletins to authorities and people at risk.

Once operational, this independent, onboard system will represent a major step forward for preparedness and for protection of people and property exposed to coastal hazards, ever more present in today's context of rising sea levels. These systems are currently still in the experimental phase.

The equipment can be permanently sited or mobile, deployed in sensitive areas or transportable and installed in different areas during emergency situations.
## 21 – Control runoff discharges in future urbanized areas and in urban renewal programs (Alexandria urban area)

### Time period
This recommendation concerns future urban developments (urban projects until the 2030 horizon). Other related sheets: 6, 22, 23, 24, 25

### Sphere of intervention
There are seven possibilities in accordance with the possible overlaps (see position of the star)

### Aim
To control runoff discharges in new urbanized areas or in urban renewal programs, in order not to increase runoff discharges downstream. This can be achieved by incorporating in urban development designs storm water drainage constraints and specific devices allowing reducing runoff discharges, taking due account of foreseeable effects of climate change. This will enable not degrading the flood protection conditions downstream.

### Targets / recipients:
 Concerns more specifically the following urban development projects: Amreya project (south-west of Alexandria), industrial zone at south Dekhila port, Monquar Al-Hodhod (south of the city).

### Expected benefits:
Avoid flood risks in new urban areas and reduce flood risks in already existing downstream urban areas by the same time.

### Scale:
Regional (the whole Greater Alexandria area).

### Description
- **Infiltration** (see Box 3):
  - Infiltration swales, porous pavement
  - according to groundwater level, and soil characteristics
  - pilot sites to be studied in order to know the efficiency of infiltration, and pollution reduction level
  - zoning of groundwater level in order to define appropriate sectors for infiltration techniques
- Include management of runoff water in urban master plans (see Sheet 6)
- Improve the efficiency of rainwater drainage systems in road construction
- **Regulation** for managing runoff water
- Regulation for creating impervious areas (ratio of green spaces to be created)

### Constraints / difficulties
- lack of space for runoff water storage
- private interests
- constructing constraints for storage on the building roofs (tightness efficiency to be assured)
- maintenance and cleaning necessary for storage areas and infiltration
- shallow groundwater (bad infiltration conditions)
### Uncertainties

Infiltration possibilities: pilot sites to be studied in order to evaluate the infiltration capacities in different types of areas.

### Concerned authorities and sectors

- Authorities in charge: Ministry of Housing, Utilities and Urban Development, GOPP (supervision), Egyptian Environmental Affairs Agency – Regional Branch, Governorate (coordination), Holding Company for Water and Wastewater, Alexandria Physical Planning Center (operators).
- Sectors: technical measures, urban planning, regulation

### Monitoring and evaluation

Changes in regulation, changes in green spaces management, number and surface area of urban projects with integrated runoff water storage and infiltration devices.

### Cost

| Institutional and regulation studies: 600 000 EGP < Ct< 2 000 000 EGP / municipality |
| Storm water drainage works: 5 Million EGP < Ct< 10 M EGP / municipality |

### Scheduling

- Short term (< 5 years)

### Joint mapping

- No
**Box 3: Integrated stormwater management**

Integrating stormwater management into urban development projects is a challenge for cities. The so-called ‘alternative’ techniques for stormwater management, unlike the conventional solution of mains collection, temporarily detain runoff and, in some cases, allow infiltration of water, thereby limiting the consequences of peak flows downstream. Combined with other urban functions such as roads and pathways, gardens and leisure and landscaped areas these techniques enhance development.

<table>
<thead>
<tr>
<th>Public areas as an integral part of urban development</th>
<th>Terraces (planted or bare)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Park able to store stormwater from a housing area" /></td>
<td><img src="image2" alt="Urban square engineered for temporary storage of runoff rainwater" /></td>
</tr>
<tr>
<td><img src="image3" alt="Floodable area in residential quarter" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planted beds for runoff water storage, detention or possibly infiltration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="A bed between two roads" /></td>
<td><img src="image5" alt="Flat roof that could be engineered for water storage" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sidewalk reservoir (porous or non-porous surface) and drainage ditches</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image6" alt="Sidewalk reservoir" /></td>
<td><img src="image7" alt="Drainage ditches" /></td>
</tr>
</tbody>
</table>

Sources: L’assainissement pluvial intégré dans l’aménagement – Certu; Water sensitive urban design – Engineering procedures – Stormwater – Australia.
2. **APPENDIX 2: Institutional Cartography**

The following tables present the main actors of natural disaster preparedness, climate change adaptation and urban planning for the three countries under study and their respective roles.

**TUNISIA**

<table>
<thead>
<tr>
<th>Entité Primaire ou de tutelle</th>
<th>Direction Générale/Office/Service/Agence</th>
<th>Rôles et mandats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministère de l’Environnement et du Développement Durable</td>
<td>Direction Générale de l’Environnement et de la Qualité de la Vie (DGEQV)</td>
<td>• élabore des plans d’actions en matière de protection de l’environnement et de la qualité de la vie&lt;br&gt;• prends toutes les mesures de nature à promouvoir la qualité et l’efficacité de l’action de l’État dans les domaines de l’Environnement, y compris celles nécessaires à l’information du Public&lt;br&gt;• coordonne l’élaboration et la mise en œuvre de programmes nationaux dans les domaines de la protection de l’Environnement et de la Prévention des Risques associés</td>
</tr>
<tr>
<td>Ministère de l’Environnement et du Développement Durable</td>
<td>Agence de Protection et d’Aménagement du Littoral (APAL)</td>
<td>• gère les espaces littoraux et suit les opérations d’aménagement de ces espaces, leur utilisation et leur occupation&lt;br&gt;• régularise les situations foncières qui n’étaient/ne sont pas conformes aux lois et règlements relatifs au Domaine Public Maritime lors de l’entrée en vigueur de la loi n°95-72&lt;br&gt;• élabore des études relatives à la protection du littoral et à la mise en valeur des zones naturelles et le développement des recherches&lt;br&gt;• observe l’évolution des écosystèmes littoraux à travers la mise en place et l’exploitation de systèmes informatiques spécialisés</td>
</tr>
<tr>
<td>Ministère de l’Environnement et du développement Durable</td>
<td>Agence Nationale de Protection de l’Environnement (ANPE)</td>
<td>• contrôle et suit les rejets de polluants et des installations de traitement&lt;br&gt;• valide des études d’impact environnemental&lt;br&gt;• contrôle et constate les infractions aux lois touchant à la protection environnementale</td>
</tr>
<tr>
<td>Ministère de l’Intérieur et du Développement Local</td>
<td>Commission Nationale Permanente pour la gestion des catastrophes</td>
<td>• prépare le Plan National d’Organisation des Secours (plan ORSEC) établissant la coordination et l’utilisation des moyens de secours à l’échelle nationale en cas de calamité</td>
</tr>
<tr>
<td>Ministère de l’Intérieur et du Développement Local</td>
<td>Office National de la Protection Civile (ONPC)</td>
<td>• participe à la préparation, mise à jour et application des plans ORSEC national et régionaux&lt;br&gt;• participe aux différents programmes et activités de sensibilisation des différentes catégories de la population à la prévention, la sécurité civile et au secourisme;&lt;br&gt;• fournit les prestations de prévention et d’expertise relatives aux</td>
</tr>
<tr>
<td>Entité Primaire ou de tutelle</td>
<td>Direction Générale/Office/Service/Agence</td>
<td>Rôles et mandats</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| Ministère de l'Agriculture et des Ressources Hydrauliques | Direction Générale des Barrages et des Grands Travaux Hydrauliques (DGBGTH) | • dresse le Plan Directeur des Eaux  
• gère les structures (barrages et lacs collinaires) entrant dans le Plan  
• coordonne les activités générales de la Direction avec celles qui relèvent des compétences des Conseils Régionaux et des Communes  
• surveille l'aménagement hydro-agricole  
• délimite les "zone d'assainissement" dans les régions cultivables en sec |
| Ministère de l'Agriculture et des Ressources Hydrauliques | Direction Générale des Ressources en Eaux (DGRE) | • élabore les plans et les programmes de mobilisation des ressources en eau et leur utilisation pour les besoins du pays  
• gère le Service des réseaux de mesures d'alerte et d'annonce des crues  
• préside au développement des ressources hydrauliques non conventionnelles et à l'économie de l'eau |
| Ministère de l'Équipement, de l'Habitat et de l'Aménagement du Territoire | Direction Générale de l'Aménagement du Territoire (DGAT) | • élabore les SDA - Schémas Directeurs d'Aménagement du territoire - aux niveaux national et régional  
• veille au respect des orientations, directives et recommandations des plans et schémas d'aménagement du territoire  
• met en place et entretient les Systèmes d'Informations appropriés dans les domaines de l'aménagement du territoire et de l'environnement  
• promeut la mise à jour des supports et des documentations nécessaires à l'élaboration des stratégies d'aménagement du territoire |
| Ministère de l'Équipement, de l'Habitat et de l'Aménagement du Territoire | Office National de l'Assainissement (ONAS) | • rédige les schémas directeurs d'aménagement des ouvrages de protection hydraulique des villes  
• réalise les ouvrages à proximité ou à l'intérieur des villes afin de gérer les écoulements des eaux orientés vers la ville |
| Ministère de l'Équipement, de l'Habitat et de l'Aménagement du Territoire | Direction de l'Hydraulique Urbaine (DHU) | • gère, exploite, entretient, renouvelle et construit les ouvrages destinés à l'assainissement des villes, notamment les stations d'épuration, relèvement, collecteurs dans les périmètres communaux, ou zone de développement touristique et industriel  
• dresse les plans directeurs d'assainissement (drainage)  
• fournit conseil en matière de pollution industrielle, de déchets solides et d'ordures ménagères |
<p>| Ministère de | Direction | • effectue les études et réalise les ports maritimes de commerce |</p>
<table>
<thead>
<tr>
<th>Entité Primaire ou de tutelle</th>
<th>Direction Générale/Office/Agence</th>
<th>Rôles et mandats</th>
</tr>
</thead>
</table>
| l’Équipement, de l’Habitat et de l’Aménagement du Territoire | Générale des Services Aériens et Maritimes | de pêche et de plaisance, ainsi que les infrastructures aéroportuaires  
• gère le Domaine Public Maritime et développe les activités de protection du littoral contre l’érosion marine |
| Ministère de l’Équipement, de l’Habitat et de l’Aménagement du Territoire | Office de la Topographie et du Cadastre (OTC) | • exécute et contrôle les travaux techniques d’immatriculation de la propriété foncière et du cadastre.  
• délimite les terres et domaines publics, ainsi que les circonscriptions administratives, les lotissements au sol et en copropriété  
• rétablit les limites de propriété  
• établit des plans touristiques et thématiques  
• exécute les travaux d’implantation et d’entretien du réseau géodésique et du réseau de nivellement de précision à l’échelle du territoire national  
• exécute et suit les prises de vues aériennes pour l’établissement des plans topographiques |
| Ministère du Transport | Institut National de la Météorologie (INM) | • est en charge de l’observation et de la prévision météorologique dans les zones terrestres et maritimes du Pays  
• assure le fonctionnement du réseau national sismique, localise les séismes et gère les données d’archive et le catalogue sismique pour la partie de compétence du bassin méditerranéen  
• coordonne et/ou effectue les études sur l’aléa sismique à l’échelle nationale |
| Ministère de la Défense | Centre National de Cartographie et de Télédétection (CNCT) | • recueille, traite, archive et diffuse les données de tous types de télédétection satellitaire et aérienne, passive et active  
• établit les cartes de base, les cartes marines, les cartes thématiques et les plans de ville, et en assure la publication, l’archivage et la commercialisation (avec accord préalable du Ministère de la Défense)  
• est en charge de déterminer les référentiels nationaux en matière de Géomatique  
• assure la gestion des infrastructures existantes ou nouvelles pour l’exécution des levées géodésiques jusqu’à la conservation des bornes frontalières du Pays  
• effectue et/ou supervise les activités de prise de vue aérienne |
| Ministère de l’Industrie et de la Technologie | Office National des Mines (ONM) | • assure la mise à disposition du public l’information en Sciences de la Terre  
• inventorie les potentialités en matières premières minérales  
• promeut le potentiel minéral et assiste les opérateurs industriels dans leurs actions sur le territoire national |
<table>
<thead>
<tr>
<th>Entité Primaire ou de tutelle</th>
<th>Direction Générale/Office/Service/Agence/</th>
<th>Rôles et mandats</th>
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</thead>
<tbody>
<tr>
<td>Ministère de l'Intérieur et du Développement Local</td>
<td>Commission Régionale permanente</td>
<td>• prépare le Plan Régional d’Organisation des Secours (plan ORSEC) établissant la coordination et l’utilisation des moyens de secours à l'échelle régionale en cas de calamité</td>
</tr>
<tr>
<td>Gouvernorats</td>
<td></td>
<td>• les Gouverneurs, de nomination présidentielle, convoquent et président la Commission Régionale Permanente, déclenchent les plans ORSEC régionaux</td>
</tr>
<tr>
<td>Conseils régionaux</td>
<td></td>
<td>• les Conseils Régionaux prennent l'initiative en matière d'ouvrages de défense contre les eaux, de drainage des eaux pluviales et de dragage des oueds</td>
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<tr>
<td></td>
<td></td>
<td>• élaborent les plans d’aménagement en dehors des zones communales</td>
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<tr>
<td>Communes</td>
<td></td>
<td>• prennent l'initiative de l'étude et de la réalisation des ouvrages de défense contre les eaux (code des Eaux, loi 75-16, section 2); niveau: lotissements privatifs</td>
</tr>
<tr>
<td></td>
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<td>• établissent les plans d'aménagement urbains au niveau de la voirie communale et du drainage des eaux pluviales</td>
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<td>• accordent les permis de bâtir au niveau de la canalisation tertiaire</td>
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**MOROCCO**

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<th>Relevant de…</th>
<th>Entité</th>
<th>Rôles / Mandats / Réalisations</th>
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<tr>
<td></td>
<td>Ministère de l’Énergie, des Mines, de l’Eau et de l’Environnement</td>
<td>• vision stratégique et prospective, gestion et développement du patrimoine énergétique et minier</td>
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<tr>
<td></td>
<td></td>
<td>• garantir la sécurité des approvisionnements énergétiques, généraliser l'accès aux services énergétiques commerciaux et assurer la sûreté des personnes et des installations énergétiques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• assurer en permanence les conditions du développement des filières des secteurs énergétique, minier et géologique</td>
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<td></td>
<td></td>
<td>• organiser et assurer le bon fonctionnement des marchés électrique, gazier et pétrolier</td>
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<td></td>
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<td>• animer et scruter les actions visant le renforcement des échanges et la concertation avec l'ensemble des administrations, organismes et partenaires</td>
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<td></td>
<td></td>
<td>• établir les bases de données et recueillir les informations nécessaires à l'élaboration des analyses à caractère économique et stratégique et des études d'impact</td>
</tr>
<tr>
<td></td>
<td>Secrétariat d'État chargé de l'Eau et de l'Environnement (SEEEE)</td>
<td>• Recherche, évaluation, mobilisation et transfert des ressources en eau</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Planification du développement, gestion des ressources en eau et sauvegarde du patrimoine hydraulique</td>
</tr>
<tr>
<td>Relevant de…</td>
<td>Entité</td>
<td>Rôles / Mandats / Réalisations</td>
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</table>
| auprès du Ministère de l’Énergie, des Mines, de L’Eau et de l’Environnement | | • Surveillance, prévision et alerte météorologiques et climatologiques  
• Recherche et Développement dans les domaines du climat et de l’eau |
• Point focal de la Stratégie Internationale de la réduction d’impact des changements climatiques et du réchauffement global  
• Mise en place des Unités de Changement Climatique, chargées de la coordination et suivi des engagements du Maroc vis-à-vis de la CCNUCC  
• Création d’un Comité National des Changements Climatiques (CNCC) qui évalue la vulnérabilité du Maroc face au CC  
• Création d’un Centre d’Information sur l’Énergie Durable et l’Environnement (CIEDE)  
• Création d’un Comité National Scientifique et Technique sur le CC (CNST-CC) à l’image du GIEC |
| Secrétariat d’État chargé de l’Eau et de l’Environnement (SEEE) auprès du Ministère de l’Énergie, des Mines, de L’Eau et de l’Environnement | Direction Centrale de la Surveillance et de la Prévention des Risques (DSPR) | • Élaboration et mise en application de la législation et de la réglementation relative au contrôle technique et à la sécurité dans les infrastructures  
• Contrôle des équipements relatifs aux hydrocarbures, gaz, électricité, et aux appareils à pression |
• Effectue des études et recherches atmosphériques, de météorologie et de climatologie théoriques, expérimentales et appliquées ainsi que les études et les recherches en rapport avec sa mission  
• Assure le rôle de référence en matière de mesure et d’observation des paramètres météorologiques, climatologiques et environnementaux en accord avec les normes et standards internationaux  
• assure la coopération bilatérale et multilatérale et participe à la préparation des accords internationaux en liaison avec les administrations intéressées dans les domaines de la météorologie et la climatologie, les échanges internationaux de données en application des accords ratifiés par le Royaume du Maroc  
• agit en Point Focal du GIEC et de l’OMM |
### Relevant de... | Entité | Rôles / Mandats / Réalisations |
|------------------|-----------------|----------------------------------|
| Secrétariat d'État chargé de l'Eau et de l'Environnement (SEEE) auprès du Ministère de l’Énergie, des Mines, de L’Eau et de l’Environnement | Agences de Bassin Hydraulique (ABH) | • Prise de mesure réglementaire et contribution à la réalisation des infrastructures de lutte contre les inondations  
• Élabore le plan directeur d’aménagement intégré des ressources en eau (PDAIRE) et veiller à son application  
• Délivre les autorisations et les concessions d’utilisation du domaine public hydraulique, tenant un registre des droits d’eau reconnus  
• Fournit aides financières, prestations de services et assistance technique pour prévenir la pollution ou la réalisation d’un aménagement hydraulique  
• Réalise des mesures, études hydrologiques et hydrogéologiques de qualité en cas de pénurie d’eau déclarée ou pour prévenir les risques d’inondation |
| Conseil Supérieur de l'Eau et du Climat (CSEC) | | • Gestion et planification de l'eau; politiques de l'eau (conception et application)  
• A été impliqué dans la loi sur les inondations  
• Examine et fournit son avis sur:  
  - La stratégie nationale d'amélioration de la connaissance du climat et de la maîtrise des impacts sur les ressources en eau;  
  - Le plan national de l'eau et les plans de développement intégré des ressources en eau des bassins hydrauliques  
  - La répartition de l'eau entre les différents secteurs usagers et les différentes régions du pays ou d'un même bassin, ainsi que les disposition de valorisation, de protection et de conservation des ressources en eau |
| Comité interministériel de l'Eau | | • présidé par le Premier Ministre, il est chargé de veiller à la mise en application des mesures recommandées par le CSEC |
| Conseil National de l'Environnement | | • Il s’agit d’un organe à représentation interministérielle articulé sur cinq commissions spécialisées. Il adopte la stratégie Nationale pour la Protection de l’Environnement et le Développement Durable |
| Ministère de l'Intérieur | Direction Générale de la Protection Civile (DGPC) | • Organise et coordonne les secours aux biens et aux personnes lors de catastrophes;  
• Assure protection et sauvegarde des personnes et du patrimoine national lors de situation relevant de la défense civile;  
• Promeut la prévention des risques, en particulier des incendies;  
• Organise et assure la gestion administrative et technique des services de secours et de lutte contre les incendies  
• Préepe et entreprend toute action de lutte antiacidienne  
• Assure la formation technique en protection civile |
<table>
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<tr>
<th>Relevant de...</th>
<th>Entité</th>
<th>Rôles / Mandats / Réalisations</th>
</tr>
</thead>
</table>
| Ministère de l'Intérieur | Centre de Veille et de Coordination (CVC) | • Coordination interministérielle et inter-agence des situations de crise  
• Déclenchement des plans ORSEC |
| Ministère de l'Intérieur | Préfectures  
Provinces  
Conseils Régionaux  
Agence urbaines | • Gestion et planification du territoire et de l'espace urbain  
• Administration, mobilisation et protection des populations  
• Gestion de crise locale et/ou participation à la gestion locale des crises nationales ou internationales proches |
| Ministère de l'Intérieur | Division des Situations à Haut Risque | • Surveillance et alerte du réseau routier  
• Résilience et réduction de la vulnérabilité des bâtiments hospitaliers et des installations techniques hospitalières |
| Ministère de l'Équipement et des Transports | Direction des Ports et Domaine Public Maritime | • Calcul et publication des marées  
• Travaux d’aménagement des infrastructures portuaires (mais gestion déléguée à l’Agence Nationale des Ports) |
| Ministère de l'Équipement et des Transports | Secrétariat d’État à l'Habitat | • Règlement de construction parasismique RPS 2000 (structures béton armé ou acier)  
• Responsabilité engagée des Architectes  
• Sanction pour non-conformité au RPS |
| Comité Supérieur pour l’Aménagement du Territoire (CSAT) | • propose les grandes orientations en matière d’aménagement du territoire  
• donne son avis sur les projets de textes législatifs et réglementaires  
• donne son avis sur les propositions d’aménagement soumises par le gouvernement  
• contribue à dresser le bilan des actions d’aménagement du territoire |
| Ministère de l'Habitat, de l'Urbanisme et de l'Aménagement de l'Espace | Délégation / Inspection régionales de l’Aménagement, de l'Habitat | • Gestion et planification de l'espace urbain |
| Ministère de la Santé | | • Contribue à développer les moyens logistiques susceptibles de faire face à une catastrophe  
• Assistance médicalisée des victimes ; triage des victimes dans le cas de catastrophe  
• Résilience et réduction de la vulnérabilité des bâtiments hospitaliers et des installations techniques hospitalières  
• Surveillance épidémiologique (prévention des épidémies après-catastrophe) |
| CRTS - Centre Royal de | | • A la responsabilité de l'utilisation, de la promotion et du développement de la télédétection spatiale au Maroc. |
### Relevant de…

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<tr>
<th>Entité</th>
<th>Rôles / Mandats / Réalisations</th>
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<tbody>
<tr>
<td>Télédétection Spatiale</td>
<td>• Coordonne et gère les programmes nationaux de télédétection spatiale en partenariat avec les ministères, les universités et les opérateurs privés.</td>
</tr>
</tbody>
</table>
| ONEP (Office National de l'Eau Potable) | • gestion et planification de l'eau;  
• politiques de l'eau (conception et application)  
• a été impliqué dans la loi sur les inondations |
| Commissions Préfectorales et Provinciales de l'Eau | • gestion et planification de l'eau;  
• politiques de l'eau (conception et application)  
• sont impliquées dans la loi sur les inondations |
| ORMVA (Offices Régionaux de Mise en Valeur de l'Agriculture) | • Gestion et planification de l'eau; politiques de l'eau (conception et application)  
• Ont été impliqués dans la loi sur les inondations |

### EGYPT

<table>
<thead>
<tr>
<th>Reference (Primary) Entity</th>
<th>Agency/ Authority/ Directorate General</th>
<th>Roles, Mandates, Duties</th>
</tr>
</thead>
</table>
| The Egyptian Cabinet | Information and Decision Support Center (IDSC) | The IDSC :  
• ensures co-ordination in emergency and crisis management  
• establishes policies and strategies in agreement with relevant ministries, agencies and NGOs, where appropriate  
• acts to develop and strengthen the national capacity in risk mitigation, disaster preparedness and emergency response  
• runs the NIMS-National Information Management System  
Chaired by IDSC, the NCCMDRR :  
• establishes national Risk mitigation plans  
• establishes national Disaster response plans  
• manages national emergencies from the situation room |
| Ministry of Interior | Civil Protection Administration (CPA)  
Governorates | • enacts national disaster response plans  
• is in charge of the training of specialized personnel  
• replicate at the regional level the national CPA duties according to Decreem no. 1/1966 of the Minister of Interior  
• according to Ministerial decree no. 382/1970, act regionally by means of own Civil Protection Unit, chaired by the Governor |
<p>| Ministry of State for Environmental | | • addresses the national Environmental policy |</p>
<table>
<thead>
<tr>
<th>Reference (Primary) Entity</th>
<th>Agency/ Authority/ Directorate General</th>
<th>Roles, Mandates, Duties</th>
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</thead>
</table>
| Affairs                    | Egyptian Environmental Affairs Agency (EEAA) | - ensures action towards Environmental sustainability in achievement of stipulated UN Millennium Goal n.7  
- to report yearly to the President and the Cabinet on the “State of the Environment”  
- to chair the Environmental Protection Fund  
- assists the Ministry of Environmental Affairs in preparing draft texts of laws and decrees, and the yearly “State of the Environment” report to be submitted to the President and the Cabinet of Ministers.  
- manages EIA (Environmental Impact Assessment)  
- is in charge of preparing Environmental contingency Plans and of supervising their implementation.  
- manages Specially Protected Areas  
- is in charge of public education in Environmental matter.  
- controls the handling and the transport of dangerous substances, pollutants and wastes |
| Ministry of Housing and Urban Development | General Organization for Physical Planning (GOPP) | - coordinates the planning processes in Egypt  
- monitors the implementation of plans  
- monitors urban extensions  
- carries out and/or supervises urban studies on transport, infrastructures and wastes |
| Egyptian Meteorological Authority (EMA) | | - Support to Civil Aviation  
- Weather report and forecast  
- Monitoring of Ozone and atmosphere pollutants |
| National Authority for Remote Sensing and Space Sciences (NAARS) | | - Spaceborne and airborne remote sensing applications to Agriculture, hydrology, Land and Land use, Risk impact scenarios,  
- Aerial photogrammetric surveys and Digital Elevation Models |
| National Research Institute of Astronomy and Geophysics (NRIAG) – Egyptian National Seismic Network (ENSN) | | - Detecting, locating and evaluating natural seismicity in the national territory and nearby  
- Carrying out accelerometric analysis of infrastructures and manufats |
| Egyptian Red Crescent | | Acts at the national, and international level on:  
- training of volunteers  
- medical response in emergencies  
- preparedness on pandemics |
3. **APPENDIX 3: FINAL REGIONAL WORKSHOP**  
**North African Coastal Cities Embrace a Climate-Smart Future**

North African coastal cities, having analyzed the risks from natural disasters and climate change, now begin the task of formulating specific response strategies, setting priorities and mobilizing the necessary financing and technical support.

The springboard for moving from analysis to action came when 70-some experts and stakeholders gathered for the final regional workshop for the research project, held at the Marseille Center for Mediterranean Integration May 30-31, 2011. The study, “Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa," found that three major cities—Alexandria, Casablanca and Tunis-- each face potential cumulative losses of more than $1 billion by the year 2030, unless they take various steps to lessen the risks. A fourth area—Morocco’s Bouregreg Valley— is undergoing major urban development, and will address the natural vulnerabilities through climate-smart planning.

The study’s overarching message for the cities is that historical coastal vulnerabilities are amplified by two trends: accelerated population increases in all four urban areas, and climate change. Population trends put more people, livelihoods and assets at risk, while climate change translates to sea-level rise, more frequent and more intense storm surges, and generally more weather-related extremes. But as part of the research effort, all four urban areas developed action plans incorporating risk-reducing programs in three spheres of response: improved urban planning, more effective institutions, and investments in strengthening infrastructures.

**Setting the Stage**

Opening the Marseille workshop **Mats Karlsson**, CMI’s director, noted that the region’s political transition translates into far greater public participation “in what kind of lives, cities and countries to create.” Timely information—such as that contained in the research project—provides a necessary basis for setting priorities. **Franck Bousquet**, World Bank Urban and Social Sector Manager for the Middle East & North Africa, called for “direct dialogue with citizens” about the ways urban spaces must evolve to prepare for the impacts of climate change, and for making sure that the collective investments carried out in the preparation of the study become tools for the implementation of resilience and adaptation actions.

**Eileen Murray**, World Bank Tunisia Country Manager, said that at a time when the country will be setting out reforms in the financial, social, and local governance sectors, it must avoid neglecting the distinct challenges posed by climate change. She added that as it enters a new phase in its partnership with the country, the World Bank stands ready to assist in the development of a new urban strategy for Tunis, which takes into full account newly available information on future climate-related vulnerabilities.

**Key Ideas for Building Resilient Cities:** Citing one of the key insights of the research, **Anthony Gad Bigio**, the World Bank urban specialist who led the study, called for experts and policymakers to integrate teams that currently focus on disaster preparedness and climate change. “The only way to come up with pragmatic solutions is by bringing these key areas together,” he said. To the extent countries count on “two separate communities”—one focused on disaster preparedness and prevention, one on climate change—integration efforts are needed. Climate change impacts constitute about one quarter of the urban risks analyzed for the time horizon covered by the study, 2010-2030, but Bigio pointed out that further out into the future, “we will see greater and greater importance coming from climate change.”
Throughout the workshop, participants underscored the enormously important role cities play as centers of economic activity, social and political organization and cultural life. Stephan Hallegatte, climate change specialist of the World Bank and Meteo France, presented data showing the disproportionate importance of cities: Lisbon, for example, accounts for 3.2% of Portugal’s land mass but 38% of its Gross Domestic Product. Alexandria, Casablanca and Tunis are similarly crucial to the economic health of their countries and the surrounding region. Egyptian delegates, for their part, noted that Alexandria accounts for 40% of the industrial activity in the country. Thus, the stakes are increasingly high in protecting the fabric of cities, enabling them to accommodate expanding populations and attract investment.

Mohamed Nbou, Director of Morocco’s Department of Studies, Planning and Forecasting, Secretariat of State for water and environment, said the two-year project “allows us to integrate management of natural risks with other elements involving climate change.”

Climate-smart planning actions might include green set-aside areas, architectural standards, or zoning requirements to minimize building in low-lying, flood-prone areas. To improve institutional functioning, cities might redefine local and national responsibilities, establish early warning mechanisms, improve decision chains or draw up emergency response plans. Infrastructure investments might reinforce coastal defenses, expand city drainage systems, or address structural weaknesses in vulnerable buildings.

**Key Ideas for Building Resilient Cities:** A number of participants focused on vulnerable communities and areas that are vulnerable because they are flood-prone, cheaply constructed or both. Often – though not always – vulnerable people settle in vulnerable areas and structures because they can afford nothing else. Morocco’s Mr. Nbou noted that some 267,000 housing structures in Casablanca are crowded, poorly built, and as a consequence are more vulnerable during a variety of natural disasters. Population growth translates to more shantytowns and slums for all three cities. Participants pointed out that relocation into sturdier housing isn’t sufficient if people are placed at greater distance from their work or from essential services.

**A Region At Risk. All the Mediterranean Prepares for Climate Extremes**

The Mediterranean, and the countries along its northern and southern shores, constitutes a critical point in the global challenge of adapting to climate change, according to Hugues Ravenel of Plan Bleu. More heat-waves and droughts, along with more frequent floods and sea surges combine in ways that create particular stresses in the region. For the North African countries, current water stresses are likely to worsen, entering a phase of physical water scarcity by 2025. Warming trends are particularly pronounced in southern Spain and Portugal and along the North African coast—particularly in the summer months.

The region accounts for 33% of global tourism, but visitors may shift their travel patterns if conditions make the Mediterranean less attractive.

Lower rainfall by 2020 could translate to a 10% reduction in cereal crops in Morocco in a normal year, with a 50% falloff in the drought year. Grazing areas, critical to herds, would be less productive.
City by City: Addressing Local Risks

Under Phase Two of the study, the cities drew up action plans for lowering each city’s risks up to 2030. Accompanying data in the studies can assist decision-makers in understanding the costs and benefits of particular elements of their action plans.

For Egypt, said Nisreen Lahham, Executive Manager of Egypt's Information and Decision Support Center, “climate change is one of the most serious challenges in years to come,” with far-reaching social and economic impacts. A national committee for crisis and disaster management has been tasked with designing policies for limiting risks arising from natural disaster and climate change.

Tamer Abougharara, Program Manager, Arab Academy for Science, Technology and Maritime Transportation, based in Alexandria, cited trends that will combine to increase risks for Alexandria and its citizens by 2030: the population will grow by 40% to about 6 million; 54% of the coastline around Alexandria will be at high risk of erosion; systems for handling wastewater and runoff will be at greater risk of being overwhelmed. Significant storms, sea surges, or events like tsunamis will pose a greater risk for the city than in the past.

Noureddine Kaabi, Tunisia’s General Director for Infrastructure in the Ministry of Development and International Cooperation, said that Tunis began to focus on the evolving severity of weather-related risks after the floods of 2003, which caused multiple deaths and injuries along with the collapse of significant structures in Tunis.

Key Ideas for Building Resilient Cities: Tunisia’s Mr. Kaabi expressed strong concerns about compounded and cumulative risks where two or more risk factors combine to imperil more people, livelihoods and structures. “We have threats of coastal erosion, and floods, the frequency of which is increasing,” he said. For all the cities, risks begin to multiply when seaboard protections deteriorate, sea levels rise, and storm surges become more frequent. With an anticipated sea level rise of only 20 cm, Tunis would see “a significant rise in areas that could be flooded,” Kaabi said, adding that flooding risks will worsen as another trend—urbanization—continues apace, with Tunis moving from about 30% of its surface area being impermeable to nearly 50% in 2030. For Tunis, the additional factor of land subsidence within the cities expands the vulnerabilities.

Morocco’s Mohamed Nbou said the study has pointed to various risks for which the country still needs strategic solutions—including growing coastal erosion along the littoral between Casablanca and Mohammedia. Currently, he added, Morocco has no program to limit the associated risks of increasing erosion, loss of beaches and threats of marine submersion, which are pronounced around Mohammedia.

Rachid Afirat, Director of Urban Planning, Agency for the Development of the Bouregreg Valley, reviewed the area’s evolving risks of erosion, flooding, and submersion, noting that seal level rise and more frequent storms could weaken coastal defenses. He emphasized the central importance of the planning function in the case of Bouregreg, which will include 30,500 new housing units, as well as industrial and commercial structures. He said that structures will be mostly situated on more elevated areas, and that reinforced protections at the coast and elsewhere, will offer added security against submersion and landslides. He added that the new development will benefit from modernized surveillance and early warning systems, as well as streamlined structures for command and control in emergency situations.
Cities Set Programs and Priorities Assuming Uncertainties

All climate change strategies are forged amid uncertainties, with ever widening ranges of possible temperature increases, sea-level rises and storm frequencies. Stephane Hallegatte, of the World Bank and Meteo-France, stressed that cities can’t escape climate-related uncertainties, but still must embrace climate-smart planning to minimize potential losses.

Every climate-related projection provides ranges of temperatures, sea-level rise and storm frequency, with the ranges widening the further the time frame stretches into the future. That said, cities have no choice but to plan for the future, since water management systems, transportation infrastructures and natural disaster protections often need to last as long as 200 years. “A building designed today needs to work under very different climate scenarios in 2070,” he said. The uncertainties don’t justify inaction, but call for a different approach to decision-making—one that allows for adjustments, mid-course corrections, and strategies that are helpful under different climate scenarios. What’s risky is locking into one approach that would be optimal under only one set of circumstances. “Strategies can be revised over time as a function of new information and knowledge,” he said.

Maryse Gautier, Operations Director with CMI, said that variations and uncertainties surround not only possible mitigation actions that may materialize among carbon-emitting nations, but also “social, biological and organizational systems that will have to react to the impacts of climate change” over time. After identifying, financing and putting into place risk-reducing adaptation measures, governments will have to evaluate their impacts, making adjustments as necessary.

Putting Specific Action Strategies in Place

The workshop focused on specific prevention and adaptation measures. All recommended actions fall into three identified spheres of response: urban planning, institutional strengthening and infrastructure improvement.

Key Ideas for Building Resilient Cities. In a panel discussion on the priorities the cities will be putting in place, Christine Kessides, urban practice manager at the World Bank Institute, said that the three spheres of action “were like a triangle, with the institutional side as the base.” She went on to say that “the institutional question determines who makes the decisions, how consensus is reached, how information is gathered and disseminated, and how policies are made and enforced.” In sum, institutional functioning significantly influences the ways that planning and infrastructure investment are carried out.

Fabrizio Ferrucci, institutional specialist with Egis International, the lead consulting firm for the two-year study, noted that Alexandria, Casablanca and Tunis all count on civil defense structures to respond to urgent natural disasters, with environmental ministries taking responsibility for issues related to climate change.

He emphasized that slow-onset risks, such as droughts, heat waves, extreme water stress and sea-level rise differ from emergencies such as earthquakes or flash floods, but he nonetheless called for shared structures and systems. He said that all three cities need improved coordination among agencies, particularly with respect to early warning systems. He called for simplified systems for decision-making and chain-of-command in times of emergency, as well as insurance and reinsurance facilities to manage risks, whether or not they relate to climate change.
Monique Terrier, a seismology and tsunami expert with BRGM, underscored the importance of managing and preparing for fast-onset risks as well as the gradual shifts associated with climate change. Her remarks reminded participants that the Mediterranean is subject to seismic risks and has experienced tsunamis in the past. Modern early-warning equipment, together with effective communications can save lives and limit physical damage, she said.

Urban planning—critical to keeping people and structures away from low-lying, vulnerable urban areas—is central to the capacity of all three cities and the Bouregreg Valley to manage changing risk scenarios, said Victor Said, Urban Planning Specialist with IAU-IDF, one of the principal consulting firms on the project. Climate-smart planning can be a high-return investment if it cuts future vulnerabilities, particularly with respect to areas slated for expansion.

For Casablanca, coastal segments subject to a strong erosion risk increase significant by 2030, with inundation risks also increasing in identified areas of the city. Planning for additional protection along the coastline, plus zoning expansion and development away from areas identified as flood prone can lead to significant savings for Morocco according to the research findings discussed at the workshop.

For the Bouregreg Valley, planning becomes still more crucial since it provides a way to lower risks before streets are paved and buildings constructed. Urban plans must include provisions for addressing specific vulnerabilities—such as reinforcing land that overhangs valley areas slated for concentrated building.

Turning to Tunis, the planning specialist noted the rising risk of flooding and marine submersion in the city. Subsidence in central Tunis and soil instability add to the threats. Alexandria, with high risks of coastal erosion, and a number of low-lying crowded slum areas, planning take on special urgency.

Consulting firm experts and policymakers alike underscored the need to increase attention on preparation, prevention and early warning systems. Tunisia’s Mr. Kaabi noted that after the catastrophic floods of 2003, the city government has strengthened prevention policies. But he added: “We’re still not doing what we should be in terms of preparedness. We still tend to act after the fact.”

North Africa’s coastal cities all need to manage carefully any expansion in low-lying, flood-prone areas or those subject to seismic risks, Said stressed. Breaking up paved over areas with open green spaces can improve drainage and protect biodiversity.

Planning also needs to take account of another climate change element—worsening water stresses and shortages. New building and population growth will increase water demand, requiring cities to adapt thorough water use plans that reflect the realities of relative shortage. Building sizes, architectural forms, and densities would all need to vary in the future. Said stressed, adding that such a mix would maximize flexibility in the context of variable climate scenarios in the future.

Yves Ennesser, Program Leader of Egis International, discussed the best approaches for infrastructure improvements. The urban risks assessments contained in the studies show the specific risks that will materialize over the next two decades, detailing the ways that climate change could increase the vulnerabilities.

**Key Ideas for Resilient Cities:** Choosing a time frame for adaptation isn’t simple, according to the World Bank’s Mr. Bigio. Climate experts often focus on the years in the middle and end of the 21st century when the most dramatic and perilous impacts of climate change would be evident, with ever warmer temperatures, ever-greater ice cap melting, and ever-higher sea
levels. However, he points out that policymakers are most likely to engage in addressing risks that will show themselves within their lifetimes, leaving future threats to the next generation. He urged the country officials to fashion “no-regret” investments and reforms that would be helpful in different scenarios, even if they require augmentation later. Experts also stressed the importance of mid-course adjustments: for example, infrastructures built in 2015 may need reinforcement in 2025 to withstand pressures expected to emerge after 2030.

He noted that all three cities face problems of coastal erosion, vulnerability to flooding, and marine submersion. All three cities, he said, would benefit from shoring up seawalls, beaches and other protective elements along the seaboard.

Since the studies identify specific weak spots in the urban fabric of each city, the challenge for policymakers will be to identify the most urgent improvements and set up a timeline for funding the changes and bringing in any needed technical assistance. For example, Casablanca has set a high priority on the construction of a “Super Collector West,” which would direct excess water away from the city center, making people and buildings less vulnerable in time of flooding or torrential rains, as occurred in December 2010.

**Moving to Implementation**

In a final discussion about moving forward in the three countries, Egypt’s Nisreen Lahham said that the country delegation had met to discuss the questions: “How can we benefit from this action that has lasted two years? How to start the next steps?” For their part, the Egyptian delegation is in the process of identifying priority actions in each of the three spheres of response—urban planning, strengthening institutions, and investing in infrastructure.

Tunisia’s Mr. Kaabi stressed the need to develop an urban plan that recognizes spatial constraints and emphasizes sound land-use practices. “We cannot expand cities indefinitely,” he said, adding that he will push for a streamlined process for planning land-use frameworks. “Currently, it is spread across too many organizations.”

Morocco’s Mr. Nbou said that Casablanca has an improved planning process for the extended city, but he said that this would need to begin incorporating the impact of climate change. Some actions, such as the construction of a Super Collector West drainage canal, are already in the pipeline.

Meanwhile, the tools for assessing risks and fashioning cost-effective solutions can be applied beyond the three countries covered in the research. CMI’s Maryse Gautier said the Center would function as a platform for exchange for the entire region, bringing together experiences and best practices as cities move forward to lower their risks.

The World Bank’s Franck Bousquet reiterated the willingness of the institution to support the countries and cities participating in the study with moving from the urban risk assessments and the preparation of action plans to investments and actions to make the cities more resilient and adapted to natural disasters and climate change. The assistance of the World Bank can be technical and financial, depending on the requests that are going to be formulated by the responsible authorities.

Interest and commitment extends beyond the three focus countries. Officials from Lebanon and Jordan said that disaster preparedness and climate change adaptation are priority concerns in their countries as well and that the focus on urban planning, institutional strengthening, and infrastructure would be applied there too, even if the specific risks differed.
Regional Workshop on Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa

Monday, May 30, 2011

9:00 to 10:45 – Opening session

Mats Karlsson, Director, CMI
Eileen Murray, Tunisia Country Manager, World Bank
Franck Bousquet, Urban Social Sector Manager, MENA region, World Bank

Anthony G. Bigio, Regional Study Coordinator, World Bank
Yves Ennesser, Team Leader, Egis International
Mohamed Nbou, Director, State Secretariat for Water and the Environment, Morocco
Nisreen Lahham, Executive Manager, Information and Decision Support Center, Egypt
Noureddine Kaabi, General Director of Infrastructure, Ministry of Development and International Cooperation, Tunisia

10:45 to 11:00 – Coffee break

11:00 to 12:45 – Cities session – moderator: Rachid Afirat, Bouregreg Valley Development Agency, Morocco

**Tunis**: Urban Risk Assessment summary
Noureddine Kaabi, General Director of Infrastructure, Ministry of Development and International Cooperation

**Alexandria**: Urban Risk Assessment summary
Tamer Abougharara, Program Manager, Arab Academy for Science, Technology and Maritime Transport

01:00 to 02:00 - Lunch

02:00 to 03:45 - Cities session – moderator: Fethi Hassine, Urban Agency of Greater Tunis, Tunisia

**Casablanca**: Urban Risk Assessment summary
Mohammed Nbou, Director, State Secretariat for Water and the Environment

**Bouregreg Valley**: Urban Risk Assessment summary
Rachid Afirat, Director of Urban Planning, Agency for the Development of the Bouregreg Valley

03:45 to 04:00 – Coffee break

04:00 to 06:00 – Regional session – moderator: Hesham Bassioni, Regional Center for Disaster Risk Reduction, Egypt

Climate change in the Mediterranean to 2030 – Hugues Ravenel, Plan Bleu

Planning for urban resilience in a context of uncertainty – Stéphane Hallegatte, Principal climate change specialist, Météo France

Sustainable Cities in the Mediterranean – Maryse Gautier, Operations Director, CMI/CDC

07:30 – Dinner hosted by the CMI
Restaurant Madie – Les Galinettes / 138 Quai du Port, Marseille
Tuesday, May 31, 2011

**9:00 to 10:45 – Action Plans session: Urban Planning**

Moderator: Anthony G. Bigio  
*Measures will be presented by Victor Said (IAU-IDF) and discussed in plenary:*
- Planning future urban expansions in low-risk zones
- Adapting the existing city and reducing urban risks
- Criteria for the design of new urban developments
- Climatic Urban planning approaches

**10:45 to 11:00 – Coffee break**

**11:00 to 12:45 - Action Plans session: Infrastructure**

Moderator: Franck Bousquet  
*Measures will be presented by Yves Ennesser (Egis International) and discussed in plenary:*
- Coastal defenses
- Urban flood protection
- Water resources management
- Earthquake and land subsidence mitigation

**01:00 to 02:00 - Lunch**

**02:00 to 03:45 - Action Plans session: Institutional measures**

Moderator: Christine Kessides, urban practice manager, World Bank Institute  
*Measures will be presented by Monique Terrier (BRGM), Fabrizio Ferrucci (Egis International) and discussed in plenary:*
- Central and local roles for adaptation and resilience
- Emergency responses and civil protection
- Public information and warning systems
- Climate and natural risks monitoring and mapping

**03:45 to 04:00 – Coffee break**

**04:00 to 06:00 – Regional session: Moving to implementation**

Moderator: Franck Bousquet  
Panel of representatives from Algeria, Egypt, Jordan, Lebanon, Morocco and Tunisia

*Summary of the workshop and the way forward – Anthony G. Bigio, WB and Maryse Gautier, CDC*

**06:00 – Closing**
ADAPTATION TO CLIMATE CHANGE AND DISASTER PREPAREDNESS IN THE COASTAL CITIES OF NORTH AFRICA
MAY 30-31, 2011 MARSEILLE, FRANCE

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